4. Notice that this third "law" differs from the first two: it has much more the character of an inductive generalization from "data"
   a. Of course, the periods, but far more so the semi-major axes, are scarcely data, for they are both being inferred from observations, especially so in the case of the semi-major axes
   b. But the evidence here akin to classical induction from cases, as well as to "curve fitting" -- i.e. formula fitting
5. Kepler's subsequent physical explanation of this law, in the *Epitome*, turned on the claim that the period is proportional to (path length ∗ quantity of matter) / (magnetic strength ∗ volume)
   a. For the amount of matter in the planet provides resistance to continued motion, and the larger the volume (*moles*), the more magnetic effect can be "soaked up"
   b. On Kepler's view the magnetic strength diminishes as 1/r (in contrast to the intensity of light, which he had correctly concluded diminishes as $1/r^2$)
   c. Thus, the "law" entailed a potentially testable consequence, viz. the ratios of densities of planets vary as $1/\sqrt{r}$; problem, of course, was to determine densities independently of it

F. *Epitome Astronomiae Copernicanae* (1618-1621)

1. The *Epitome* was published in three separate installments, covering three different subjects:
   a. Books I-III (1618) dealing with (largely conventional) spherical astronomy
   b. Book IV (1620) dealing with theoretical astronomy, including discussions of underlying physics -- "Celestial Physics, i.e. Every Size, Motion, and Proportion in the Heavens Explained by a Cause Either Natural or Archetypal" -- preceding Books V-VII
   c. Books V-VII (1621) dealing with practical geometric problems that arise in the new astronomy; V on orbital geometry, VI on the individual planets, VII a rap-up with comments on Ptolemy etc.
2. With its three opening books on spherical astronomy, it was clearly intended to be a comprehensive text in astronomy for universities
   a. A textbook in Copernican astronomy, more accessible than Copernicus's *De Revolutionibus*, yet presenting not Copernicus's system, but the "Copernican-Keplerian system" -- "the Copernican system as expostulated by Kepler," to quote Newton's statement of the matter
   b. But with a large amount of conjectural physics, from which the motions are derived, and complicated efforts on a number of recalcitrant problems, most notably that of the Moon
   c. Confidently Copernican, and not Tychonic, because so much of this physics turns on the Sun; indeed, offers 18 reasons to reject Tychonic (pp. 71-78), none knockdown
3. Successful as a textbook -- e.g. reissued in 1635 after the initial successes of the *Rudolphine Tables* began securing converts
   a. "For many years it remained one of the few accessible sources for the details of the Copernican system (including, of course, those essential revisions introduced by Kepler)" -- Gingerich, p.75

b. As such, completely replaced *Astronomia Nova* as the fundamental work of Kepler, as well as replacing *De Revolutionibus* (and as Kepler announces, Aristotle's *De Caelo*)

c. Because the reasoning in it proceeds from physics to orbits, the more predominately astronomical reasoning of *Astronomia Nova* -- i.e. reasoning from observations to orbital motions -- becomes lost from view, as does some of the continuity with earlier astronomy

4. Includes a treatment of the moon covering Ptolemy's inequality; the inequality called the "variation," discovered by Tycho; and a new inequality, the annual equation, discovered independently by Tycho and Kepler

   a. All depend on the position of the Sun vis-a-vis the Earth and Moon

   b. "Kepler realized that any physical theory must involve a double interplay of the Earth and Sun." -- i.e. Moon, driven by emanations from both Earth and Sun -- (Gingerich, p. 75)

   c. This was Kepler's second published cinematic model of the moon; an earlier one in the ephimerides of 1617 stayed faithful to the area rule

   d. Whatever else may be said for them, both models fall far short of the level of accuracy in predicting longitude and latitude of the Moon achieved by the model for Mars

5. In a way, a revolution in astronomy textbook writing, for includes physics and mathematical astronomy together, unlike e.g. Ptolemy and Regiomantanus's *Epitome of the Almagest*

   a. As Kepler himself says, "You might doubt whether you were doing a part of physics or astronomy, unless you recognized that speculative astronomy is one whole part of physics." (p. 5)

   b. Even though most key readers ended up discarding the physics early on, they did not discard the need for a physics to the same extent

G. *Tabulae Rudolphinae*: The Culmination (1627)

1. The closest Keplerian counterpart to Ptolemy's *Almagest* insofar as it includes no physics, but only mathematical astronomy; really though, Kepler's counterpart to Ptolemy's *Handy Tables*

   a. 275 pages explaining how to use the Tables (including how to use logarithms) and in some places giving some background on the orbital elements

   b. Followed by 104 pages of tables and then a star catalogue

2. The frontispiece summarizes Kepler's own view of where he fit into the process of reforming mathematical astronomy

   a. Main pillars for Copernicus and Tycho, but pillars to Ptolemy, Hipparchus, etc.

   b. Emphasis on Tycho, Hven, etc. because of the critical role of Tycho's observational efforts, which Kepler never belittled, and the project of the Tables having originated with Tycho

   c. Kepler in basement toiling on calculations by candlelight, with a few coins on the table

3. Kepler's orbits are simpler than they first appear, involving one set of elements pertaining to heliocentric longitude, another pertaining to heliocentric latitude, and the third pertaining to location of the planet at some epochal time