Chapter 5: Doubt and Discovery

Copernicus issued a basic challenge to the medieval-Aristotelian worldview by asserting that the earth was just another planet. Alexander Koyre calls the ensuing revolution "the destruction of the Cosmos," the rejection of the universe as a closed, finite, highly ordered system, extending from a corrupt but unique earth on up to the higher perfection of the stars. Ultimately, this challenge was an implicit rejection of the old hierarchy of value presented to mankind in the created Cosmos. Yet this hierarchy was upset in a curious way. In the old system the earth may have been corrupt, but it was gloriously unique as the focus of the universe. From this new perspective, the earth was neither corrupt nor unique and had the same status as the other planets, which therefore could no longer be considered heavenly bodies without also according a divine nature to the earth. How could such a confusing, radical change in viewpoint possibly take root? Even at the beginning of the 17th century, long after the death of Copernicus, Europe was still secure with a medievalized Ptolemy:

> *Animals, which move, have limbs and muscles; the earth has no limbs or muscles, therefore it does not move. It is angels who make Saturn, Jupiter, the sun, etc., turn round. If the earth revolves, it must also have an angel in the center to set it in motion; but only devils live there; it would therefore be a devil who would impart motion to the earth...The planets, the sun, the fixed stars, all belong to one species — namely that of stars. It seems, therefore, to be a grievous wrong to place the earth, which is a sink of impurity, among these heavenly bodies, which are pure and divine things.*

Yet, by the end of the 17th century theologians were attempting to do for the post-Copernican ideas of Newton what Aquinas had done for Aristotle. Copernicus had set the stage, but just as important were his successors Galileo, Brahe, and Kepler. The 17th century embraced a new optimism regarding the prospects for natural philosophy, a revival of that earlier Greek confidence in the power of the intellect and the potential of mathematical reasoning, but now coupled with a stirring of the empirical spirit — honest and vigorous observation and experimentation.

People were making better instruments and better measurements. In particular, Galileo Galilei was making and using telescopes for astronomical observations. Not since Archimedes (with the possible exception of Leonardo Da Vinci) had someone taken observation and experimentation so seriously. Galileo's approach to natural philosophy was direct. He would doubt anything told him that he had not yet demonstrated to his own satisfaction through direct observation, particularly those neo-Aristotelian "truths" held by some “traditional” scholars of his time (i.e. proponents of lingering medieval scholarship based on mindless appeal to authority rather than rational/empirical inquiry). Galileo had no patience with such thinking. He would subject such “truths” to experimental test, disprove, and then ridicule them and those who supported them. Although his university colleagues were not particularly fond of this technique, it was quite popular with students.

Even though he continually attempted to promote the Copernican view because it appealed to him philosophically, he was never able to provide any observational confirmation. Rather he contributed in a major way to the general erosion of the medieval World picture, to the breakdown of the sublunary-superlunary distinction. He directly challenged the divinity, perfection and immutability of "heavenly" bodies.

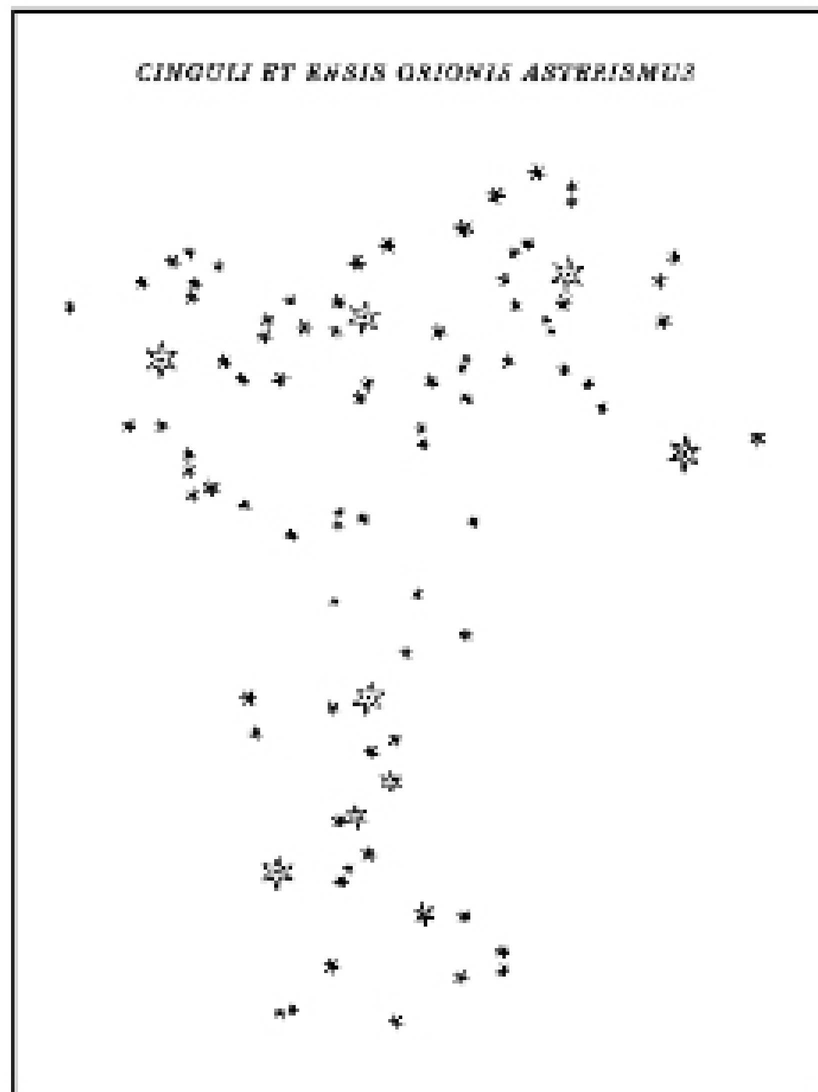


Fig. 5a.

In addition to well-known naked-eye stars in the constellation Orion (larger star symbols in this diagram), Galileo discerned many others with his telescope.

All of this was made possible by a major technological breakthrough, the telescope. Galileo did not invent this device, but he was the first to use it for serious scientific purposes. After observing the night sky for a few months he quickly prepared a small monograph in 1610 entitled *Siderius Nuncius* (Sidereal Messenger) in which he described with some relish a series of observations which contradicted the comfortably held but totally unconfirmed conceptions of his contemporaries:

1. The moon could not be a "heavenly" body because it was seen to be "imperfect", to be marred by mountains and craters.
2. Many more stars existed than could be seen by the unaided eye. If man was the central figure of creation, what purpose or meaning could invisible stars have?
3. Venus was seen to have phases much like those of the moon. This was direct evidence that Venus circled the sun. An objection to the heliocentric model had been the fact that phases were *not* observed for Venus. The changing phases were a major contribution to the change in brightness of this planet as observed with the naked eye.
4. Galileo was elated to find another planet with not just one satellite but four. The moons of Jupiter were a key issue in the Copernican controversy because the special role of the moon was considered to be untidy (all other bodies orbited the sun). Galileo as usual, showed the unthinkable to be commonplace.
5. In a later publication on the sun he noted that it also was less than perfect, plagued by transient blemishes (sunspots) and thus subjected to change and decay — conditions hardly appropriate to divine perfection. Furthermore, by observing the motion of these spots across the face of the sun, the rotation of the sun was established. By analogy the rotation of the earth seemed to Galileo not only feasible but inescapable.

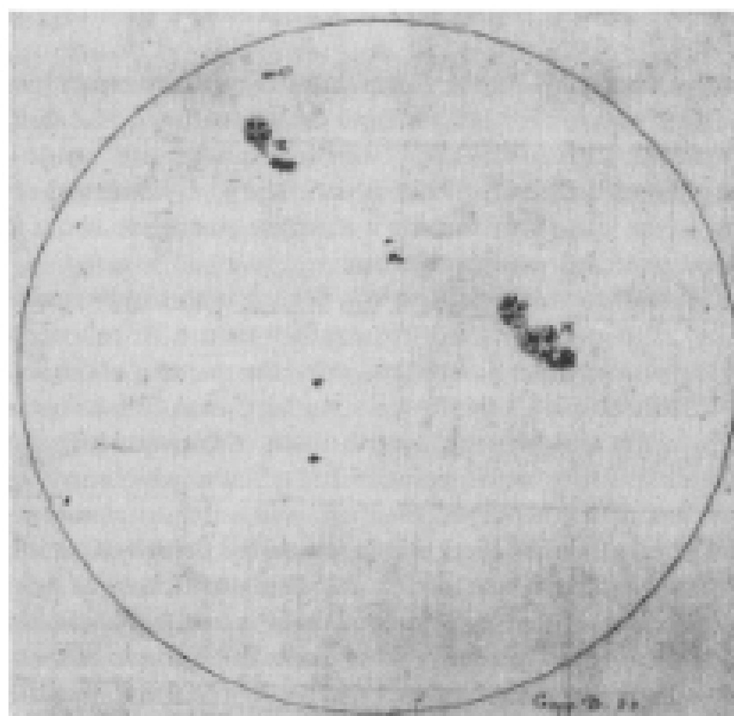


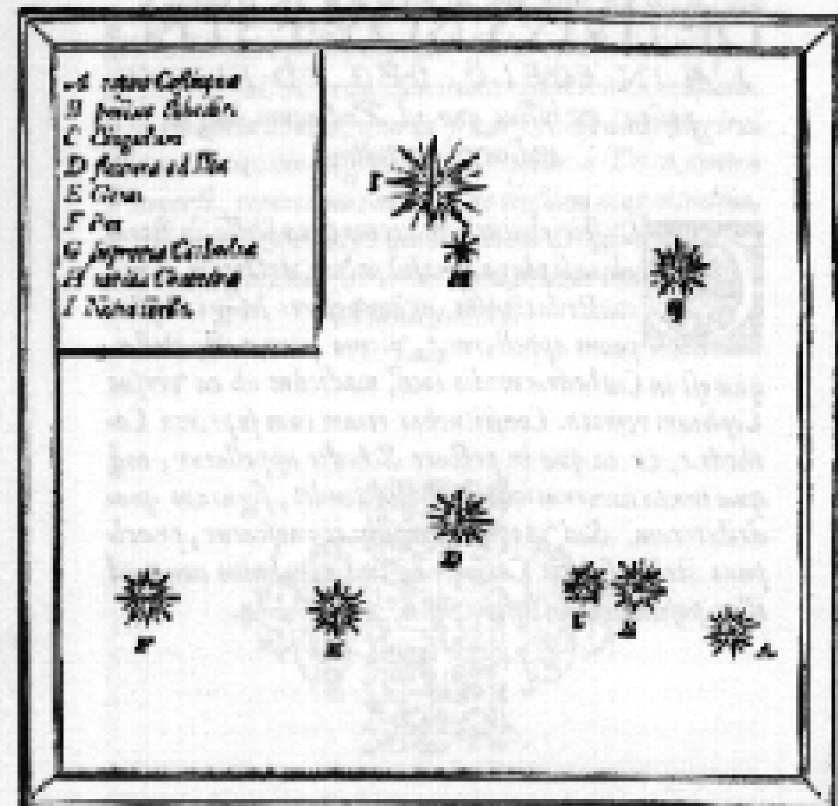
Fig. 5b. Sunspot drawing by Galileo.

None of these revelations indicated the earth to orbit the sun, however. Such evidence was requested by Cardinal Bellarmine in 1615 who commented that if the heliocentric theory could be verified, "then we should have to proceed with great circumspection in explaining passages of Scripture which appear to teach the contrary, and we should rather have to say that we did not understand them than declare an opinion to be false which is shown to be true."

Galileo's reply in 1632 to this and other questions and criticisms was contained in his "Dialogue On the Two Great World Systems" in which he set forth seemingly unassailable arguments for the Copernican system over against that of Ptolemy. It was a stinging devastation of Aristotelian physics posed in that uncompromising, offensive manner which he had mastered early in his career. In the controversy with Rome (Bellarmine) the overriding question for Galileo was whether the substance of natural philosophy was to be legislated by authority rather than observation and intellectual honesty. For the church, the question was who had the authority to interpret scripture. As Galileo found out, the 17th century Church was very capable of handling questions of authority. It is interesting that Galileo's ridicule of medieval physics, ideas about motion, etc., was phrased in terms of terrestrial experiments. He did not apply these new ideas to the heavens. There is perhaps a limit to how much dogma can be stripped away by a single individual. Even for Galileo, it seemed only right, that celestial bodies should follow uniform, circular motion.

Fig. 5c. Frontispiece of Galileo's *Dialogue On Two Great World Systems* showing Salviati, Segredo, and Simplicio, the three philosophers whose conversation comprises the text.

Tycho Brahe, a Danish nobleman, was another colorful personality who turned his attention to improving the science of astronomical observations. His work, begun in 1563, was significant to the continuing philosophical controversy over world systems as well as supplying Johannes Kepler with a large body of (crucial) data on the changing positions of planets relative to the background of stars. Through the invention of improved measurement devices and techniques, he established a new standard for precision in astronomical observations.



Distantiam verò huius stellæ à fixis aliquibus in hac Cassiopeiæ constellatione, exquisito instrumento, & omnium minutorum capaci, aliquoties obseruaui. Inueni autem eam distare ab ea, quæ est in pectore, Schedir appellata B, 7. partibus & 55. minutis: à superiori verò

Fig. 5d. The larger star in the upper left represents the "Stella Nova" discovered by Tycho Brahe. The diagram is from his own work.