Remote Learning Module for 20 April 2020

Lecture Notes for Fernando Espinoza's *The Nature of Science,* Chapter 6

— The New Sciences of Modernity —

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Last time we considered the beginnings of modern science and philosophy as the Renaissance came to a close, and the tensions between Hellenic and Hebraic thought reached a point of crisis that so overwhelmed Western culture that new foundations for both natural and moral philosophy emerged in the wake of the Copernican Revolution and the Protestant Reformation. Today we'll continue our exploration of how the Modern Worldview came to displace Mediæval and early Renaissance problems and projects in science and philosophy. We'll examine what the Early Moderns called the "New Science" (*Scientia Nuova*) of Nature, first by a consideration of advances in Methodology, and then by a quick tour of how these advances played out in the history of astronomy.

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— Methodology —

The question of scientific methodology was a crucial one for the modern period, especially for the Continental Rationalists for whom epistemology and science were fundamentally equivalent. Before the modern period, basically three schemes were available to the investigator who wished to pursue in a rigorous manner the study of Nature.

1. Platonic Dialectic: the method of difference or division

— We begin with an unclear, poorly defined concept (like motion, heat, justice, friendship), and by *contrasting* various intended/suggested definitions with one another, we approach a clear concept.

E.g.: Justice:
1. justice is "same to all" [excludes preference to any]
   ** but some are more deserving than others
2. justice is "each according to deserts" [excludes compensation for original impediments]
   ** but some who deserve less need more
3. justice is each according to merit + handicap
4. ....?

2. Aristotelian Syllogistic: the method of categorization, or chains of definition linked by deductive inference

E.g.
All corporeal things are corruptible
All men are corporeal
So, all men are corruptible
All corruptible things are mortal
So, All men are mortal

Socrates is a man
So, Socrates will die someday.

3. Euclidean Demonstration: the method for mathematizing space: where the proposition to be proved comes first; there are no unknowns.

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TWO NEW METHODS SURFACE AT THE DAWN OF MODERNITY

1. Hypothetical Inference from accumulated observation: what we now call **Baconian Induction** (after Francis Bacon [b.1561 three years before Galileo, b.1564).

◆ Bacon, although a contemporary of Galileo's, evolved a rather distinct notion of scientific method: at the height of the English renaissance he represents the *last mediaeval* (still conceiving that things have essential natures, rather than thinking strictly in terms of *events and relations among them.*

◆ Bacon had two cardinal notions:

1. Although various presuppositions (which he called "idols") can obscure reality from the inquiring intellect, the mind, properly guided, can be a perfect MIRROR OF NATURE.

2. Proper guidance consists in the method of HYPOTHESIS.

_◆ The Hypothetical Method:

For each thing to be explained, we generate four lists:

(a) Table of Essence and Presence	(positive instances)
(b) Table of Deviation	(negative instances)
(c) Table of Comparison	(degrees)
(d) Process of Exclusion	(exclude all explananda that don't square with the tables)

**** Baconian Hypotheses are **unweighted**: the problem with this, of course, is that Bacon does not tell us how to *get* the hypotheses which we'll exclude by his process; it would appear that after seeing enough facts, hypotheses suitable for testing will just leap out; but this is not at all obviously true.

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ON THE CONTINENT

◆ A dramatic change occurs with the adoption (by Copernicus, Brahe, Kepler, and Galileo) of

Quantitative Method:

1. Convert qualities/sensuous impressions into quantities (#'s):

   Motion isn't fast/slow, heat isn't warm/cool; *but*

   ◆ velocity = feet per sec.
   ◆ acceleration = feet per sec. per sec.
   ◆ heat = degrees on a scale

2. Mathematical logic (implication) + computation instead of syllogistic to **weight hypotheses.**

3. Verify hypotheses by precise instruments yielding quantitative data.

In order to appreciate the scope of these new methods, we'll look at how they surfaced with Copernicus et al. with a brief look at the history of astronomy.

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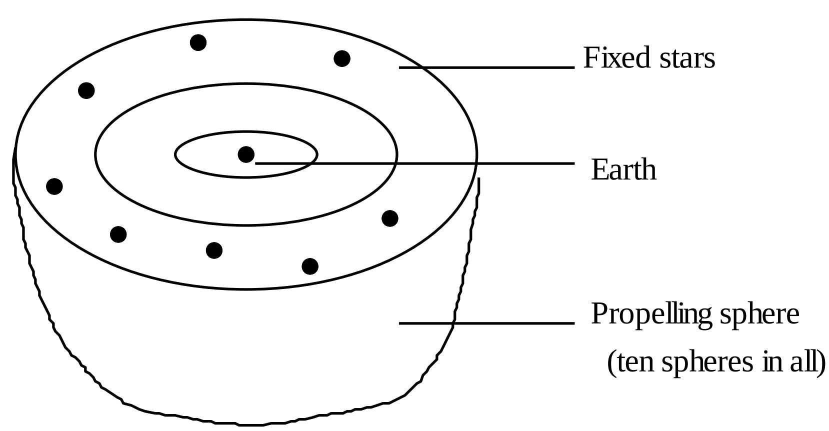
— Astronomy —

1. **Pythagoras**: he was the first to posit a **spherical earth**; planetary motion (within crystal spheres) disturbed the air surrounding the planets to produce vibrations; these spheres made music as they moved [moon=bass, the stars=falsetto; this order was reversed for Kepler].

2. **Plato**: used a Pythagorean model, but without music (which Plato thought was a silly idea). Plato imagined that the planets are suspended in spheres like nested bowls whose rims were "whorls" that carried the planets along

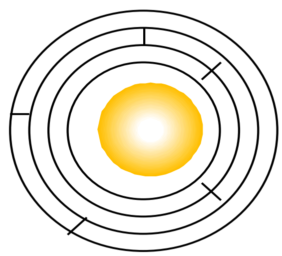


Plato also gave to astronomy the problem we now call **Plato's Problem**: Why do we not see perfect circular motion when we observe the planets and stars? The picture is perfect, with the motions perfectly circular, but observation reveals *retrograde* motion: sometimes the planets appear to reverse their courses; so Plato asks:

"What are the uniform and perfectly ordered motions, by the assumption of which the apparent motions of the planets can be accounted for?" He puts his disciple, Eudoxus (author of the 5th book of Euclid's *Elements*) to work on it.

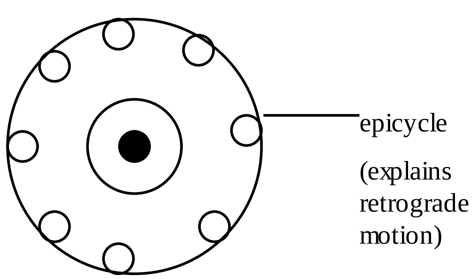
3. **Eudoxus**: came up with a great idea: **add more spheres:**

One for daily motion, one for yearly motion, one for position on the horizon (sun & moon), and one for certain other irregularities (other planets and stars with inclined axes; the planets have 4 spheres each, the sun and moon have three each to account for all the motions observed.



4. **Aristotle**: he liked Eudoxus' model just fine, but added three more spheres per orbit; this was a really ingenious idea, all things considered: the added spheres would thus cancel the *mechanical* effects of the outer spheres on the inner spheres, so as to leave the background of the fixed stars intact. So, for Aristotle, there were 56 spheres in all, driven by one unmoving divine sphere which moved by final causality: the desire for perfection.

5. **Ptolemy** (126-61 BCE): Aristotle's spheres got rather cumbersome as measurements improved. Relying on other theorists (Heraclides, Hipparchus, Appolinus), Ptolemy suggested that cycloid motion is the cause of retrograde observations; he therefore introduce a system of epicycles (circles on circles):



79 epicycles are needed; each planet's orbit is an epicycle along a **deferent** whose center is a little off the earth's center

THE MEDIAEVALS

In the same way that textual authority came to supplant speculative inquiry in other areas, so too with astronomy.

1. The Mediaeval picture was of a flat (disk/circle) earth with a dome shaped heaven. They got this idea from Isa 40:22: "It is He that sitteth upon the *circle of the earth*, and the inhabitants thereof are as grasshoppers; that stretcheth out the heavens as a curtain and spreadeth them out as a *tent* to dwell in."

2. The motion of the sun was taken from Eccles. 1:5: "the sun also riseth and the sun goeth down, and hasteth to his place when he arose."

3. We do well to note the strangeness of Mediaeval addictions to hierarchical explanation.

   E.g.: when the Irish monk Fergil (Virgilius of Salzburg) (767) taught the existence of the *Southern Hemisphere*, Pope Zacharius held a council to excommunicate Fergil for heresy.
   ** **But** he was later canonized a saint (in 1223) for having left miraculous bones (dug up in 1171); his heresy was explained away on the grounds that he had, after all, held to a fixed, flat earth.

4. Aristotle was banned by the Provincial Council of Paris in 1209, but by 1225 (the birth of Thomas Aquinas), he was studied again openly. Aristotle's works spread like wildfire: his logic was both enticing and compelling; but the spirit of the age was still heavily devoted to scriptural interpretation. Aquinas is the stellar example: for him the task of the philosopher/theologian is to reconcile faith with reason.

5. When the Franciscan, Roger Bacon (1214-1294), Aquinas' contemporary, read Ptolemy, he admonished the Church to abandon literal interpretation of Scripture because of obvious contradictions with fact: for his troubles, he was accused of witchcraft, and imprisoned for 10 years. His work was not to appear in print until 1700, 400 years after composition.

6. Astrology, however, despite its general condemnation as *science* (not religion), flourished. Pope Leo X (1475-1521) established the first chairs of Astrology at the Universities of Rome & Oxford.

7. Meanwhile, the Arabic and Jewish astronomers preserved and furthered the study of Greek astronomy; they established observatories and drew up extensive star catalogues with amazing degrees of precision.

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THE RENAISSANCE

1. With the rise of Humanism in the 15th and 16th centuries, new theories arose with the new spirit of open speculation.

2. One notable example is **Nicholas of Cusa** (1401-1464)
   His maxim was that "God is a circle whose circumference is everywhere but whose center is nowhere; he held that the universe is infinite (has no center), and that the Earth is not fixed/stationery (he also anticipated Galilean relativity, holding that one can perceive motion only relative to fixed objects). Although Nicholas argued from Neoplatonic abstraction rather than careful, precise mathematical observation, he did anticipate the cardinal features of the *Copernican Revolution*:

** The Earth rotates (it is not fixed); and orbits the sun between Mars and Venus with the Moon on an epicycle.

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COPERNICUS.

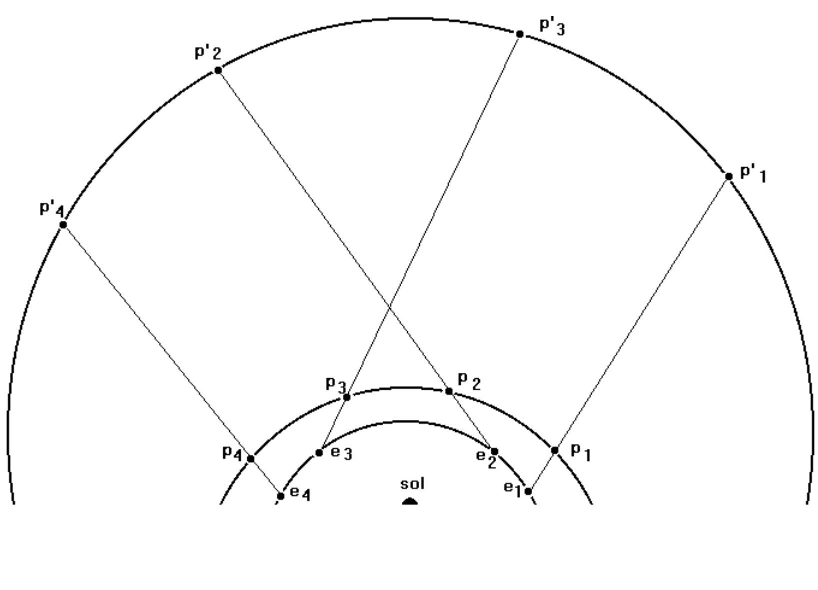
Copernicus studied at the University of Cracow, Poland (his uncle was Bishop Waczenrode).

He sought the cannonry at Varimia (vacant in Sept, an odd month, so mandated by the Pope, not, unfortunately for Copernicus, a Bishop); but the next year, the Frauenberg cannonry became vacant in August, and Copernicus got the job.

He then went to Bologna, Italy, to study astronomy and astrology, where he became known as the **Astrologer of Bologna**; here he corrected the obliquity of the ecliptic, proving that the North Pole shifts in relation to the North Star, already showing that Ptolemy was wrong.

The first inklings of his model for the new solar system appear in the *Commentariolus* (or "Little Commentary"), where he sets out his "Assumptions" (all mathematically demonstrated):

1. There is no one center of all the celestial circles or spheres.
2. The center of the earth is not the center of the universe, but the center of gravity and of the lunar orbit.
3. The sun is the center of the universe; all the celestial spheres revolve around it.
5. Whatever motion appears in the firmament (fixed stars) is caused by the rotation of the earth on its axis.
6. The earth also revolves around the sun, therefore having two motions.
7. The apparent retrograde motion of the planets arises solely from the motion of the earth.



Notes on the scientific resistance to Copernicanism

1. No gain in predictive power or descriptive accuracy over Ptolemy.

2. Without instruments:
   (a) the planets look pretty close;
   (b) and they appear to be made of light (ether/fire), while the Earth seems massive and immobile by comparison.

3. Hierarchy of the elements (earth, water, air, fire)
   + Aristotle's principle that facts and values are *commutative* suggests that, in comparison to the Earth, the fiery planets would necessarily be
   (i) more noble; and
   (ii) more mobile.

4. People don't fall off the earth; a more refined version of this objection: vertically propelled projectiles should fall considerably to the West of their origin; but they don't.

5. The fixed stars should reveal an annual parallax proportional to the 186 million mile shift in the di-annual position of the earth [actually measured by Bessel in 1838].

So, why fly in the face of all this?

1. Simplicity: from 79 to 34 epicycles; and because Plato's problem can be solved solely by the motion of Earth [note: Occham's Razor: *natura nihil facit frustra*].

2. Comprehensiveness: one physics for both celestial and terrestrial motion

3. The Copernican model is more amenable to algebraic rather than geometric methods for the reduction of complex geometric figures to simples.

4. Labor saving: it is Galileo who raises this idea fully to a principle of knowledge.

5. Understanding Astronomy as the Geometry of the Heavens is immensely fruitful, because in geometry no points of reference have absolute position, and any point can be chosen as the reference point for the entire spatial system under construction. Copernicus suddenly realizes that the only thing supporting Ptolemy is HABIT.

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KEPLER.

Kepler takes the spirit of things further by reviving *Pythagoreanism* and discovering mathematical empiricism. The empiricism he got from Tycho Brahe: precise measurement; the Pythagoreanism followed: perfect algebraic (numerical) relations are more beautiful than their shadows in geometry (actual space), so the latter is to be explained in terms of the former.

GALILEO.

Galileo's contributions were many; we saw some of them earlier in the semester. For now, let's note in particular the following:

1. Mechanical explanation overrides teleological explanation. We do not ask *why* bodies fall, but *how*.

2. Galileo invents the science of *dynamics*, thus showing how to reduce all terrestrial motion to exact mathematical expression; he formulates the mechanical/dynamical laws governing these motions.

3. What is of primary important here is that for Galileo, physical truths become necessary and inexorable, not relative to the adequacy of our human attempts to second-guess God's intentions. God ceases to be the Ultimate Good, and becomes the Ultimate Horologist, the Ultimate Engineer.

4. The subjectivity of **secondary qualities.**

(a) Nature, in itself, is *independent* of human intelligence; nature is absolute, objective, immutable, and *mathematical.*

(b) All variable, qualitative properties are *subjective* to the mode of their apprehension, i.e., they *depend* on the human perceiver, having no reality independent of that perceiver.

So there are two sorts of qualities of matter:

Primary: number, shape, size, position,
/ momentum, mass

PHYSICAL OBJECTS

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Secondary: color, taste, texture, odor,
sound: names for ways nature
affects us.

Consider a feather: it has motion; motion belongs to it, but it doesn't possess the tickling faculty, which disappears without a human to sense it.

**** Humans become the effects of Nature, not final causes.

→ To understand human beings, therefore, we must subject ourselves to the same sort of exact mathematical study as we apply to astronomy;

→ Our subjectivity must be "read out" of metaphysics: our perceptions are not primary and fundamental, but secondary, and need to be *explained* with reference to objective truths of nature.

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Next time, we’ll look more deeply into the achievements of Galileo, Hobbes, and Descartes. Be well everyone, and, although I imagine you are probably quite tired by now of my continuing to say so, do remember: social distancing continues to save lives, which is presumably why we are still not in JUB 202 presently.