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Transformation of Western Thinking:

The Displacement of Aristotelian Cosmology through the Rise of Mechanical Philosophy

In the sixteenth and seventeenth century, post-Medieval era Europe witnessed shifting sociological ideologies that contributed to the surge of scientific thinking and experimentation, now known as the "Scientific Revolution." The Renaissance, Protestant Reformation, and Age of Exploration intertwined with and influenced the Scientific Revolution. Mathematicians and philosophers like René Descartes, Nicholas Copernicus, Galileo Galilei, Robert Boyle, and Isaac Newton completely transformed the outlook of the western world, one that had earlier generally adhered to the principles of the Greek philosopher, Aristotle. Descartes emphasized a system of skepticism and methodical thinking, Boyle outlined the mechanical philosophy as an instrument of reasoning, Copernicus and Galileo advocated cosmological models that generated social upheaval, and Newton symbolized the pinnacle of this era through his profound discoveries and viewpoints. Although the influence of the Aristotelian doctrine lasted several centuries, the principles of the mechanical philosophy advocated by these thinkers sharply contrasted particularly in the characterization of nature, examination of matter and motion, differentiation between perception and reality, assertion of the scientific method through the mathematization of nature, and generation of teleological explanations with the evidence of accurate cosmological models.

Aristotle's philosophical method was based not only on observing a phenomenon but also on explaining why it came into existence. He argued that every natural being consisted of matter and form. This concept is known as hylemorphism. According to Aristotle, in order for change to occur, passive matter had to undergo change and the form had to remain constant. He further differentiated between types of form—substantial form and accidental form. Substantial form determines the properties of a substance, while accidental form describes its unimportant characteristics. In particular, Aristotle emphasized substantial form and changes on a microscopic scale, but did not consider the "true accidents" that occurred in the microscopic level—thus indirectly criticizing the atomists. In order to explain a phenomenon completely, Aristotle developed a taxonomic breakdown of causalities which consisted of the four causes—efficient, material, formal, and final causes. The efficient cause describes transformations through the interaction with the source of the change, while the material cause analyzes change due to composition of the matter. Formal cause illustrates the essence of the material or phenomenon itself, while the final cause concentrates on the end goal or purpose of its existence. One of the main inspirations of Aristotle's final cause was his attempt to provide teleological explanations. A consequence of this idea results in Aristotle's idea of a "prime mover," one that is both efficient and final. The prime mover, or the unmoved mover, is the ultimate source of change, which indicates Aristotle conceptualizing the existence of a superior being in order to provide explanations for perplexing issues. He proclaims that the combination of all four causes is necessary to explain the existence of a certain phenomenon; specifically, these causalities are not mutually exclusive. Altogether, Aristotle formalized the explanations of various natural occurrences by the means of his four causes.

While Aristotle's method of explanation was guided by his four causes, his root of knowledge was based on experience and observation. The major elements of the Aristotelian philosophy revolved around observing nature, categorizing substances and their properties, and determining the place of humans in the cosmos. He generalized the fundamental constituents as earth, air, fire, and water, which are cold and dry, hot and wet, hot and dry, and cold and wet respectively. He deduced that a substance's property is established by its "ultimate subject of predication," and its actuality is produced by the activation of its potencies. He believed in a spherical cosmos, one that is enormous yet finite, eternal, and celestial. In addition, he did not believe in a vacuum, and therefore conjectured a space completely filled with matter. Aristotle deemed humans to be composed of primary matter and substantial form. He conjectured that they are distinct because they are political and rational animals. Furthermore, he supported the Ptolemaic astronomy, where Earth is the center of the cosmos. This rationale suggested that Earth, and humans specifically, were distinctively unique—and thus, at the top of the pedestal in the great chain of beings. He proclaimed that humans had a final cause and a free will. The Aristotelian inclusive world placed nature at the forefront, based its philosophies on everyday experiences and observations, and attempted to explain incidents through a series of rational causalities. As a whole, Aristotle's influence lasted undeterred until the mechanical philosophers refuted his philosophies centuries later.

The mechanical philosophers strived to explain nature and other "mysterious forces" through "simple mechanical principles" (Bowler and Morus 35). Descartes proclaimed that "machines built by artisans" and the "diverse bodies [of] nature" are alike, an idea central to the identity of this philosophy (Shapin 32). Natural phenomenon could be explained by mechanical principles in this philosophy. Portraying nature as a machine, though, "counted as a violation of one of the most basic distinctions of Aristotelian philosophy" (Shapin 30). Aristotle derived his knowledge by observing nature, not by explaining nature through mechanical principles. These philosophers employed the clock-metaphor in order to explain various occurrences like "human respiration, digestion, locomotion, and sensation" (Shapin 34). One of the consequences of utilizing the clock-metaphor was the doctrine of "determinism." If nature works as efficiently as the mechanics of the clock, then everything must already be put into place and be determined. This notion reduces the idea of a free will, which is contrary to the Aristotelian world view. All in all, the emergence of determinism due to the characterization of nature through mechanical processes was a distinction from the Aristotelian philosophy.

Matter and motion were also central to the mechanical process and were the foundations of materialism and reductionism. Materialism conceptualizes the view that every entity is made of matter. The mechanical philosophers described this as unchangeable, lifeless, and inert matter. To understand matter, the mechanical philosophers utilized "corpuscles," basic particles making up matter, thereby reviving some elements of the ancient atomism theory. Boyle asserted that all things in nature could be reduced two significant elements, "indefinite divisibly of matter" and "efficacy of motion" (Boyle 265). These two ideas were essential to the overarching philosophy because it made the mechanical principles "fairly reducible or reconcilable" (Boyle 268). The structural explanation of a natural phenomenon could be explained by referring to the underlying structure of the particle. This highlights the idea of "reductionism," in which all things in nature can be reduced to the matter in motion. Any incidents that are observed in the macroscopic level can be explained by occurrences at the microscopic level. Reductionism is in stark contrast to the Aristotelian philosophy, where explanations took place at the macroscopic level in the form of "substantial form" and not at the microscopic level. The cause of change for the mechanical philosophers was strictly passive matter impacting other passive matter in motion. Galileo, for example, declared that “motion is the cause of heat” after analyzing how corpuscles interact with each other (Galileo 10). Explaining occurrences through transformation in matter and motion was a much more definitive reason for change compared to the vague explanations offered by Aristotle’s four causes. Overall, the focus on matter and motion emphasized a key foundation of the mechanical philosophy.

Apart from the technical differences, the question of perception and reality is a distinguishing factor between the mechanical philosophy and the Aristotelians. Galileo’s differentiation of primary and secondary qualities was an essential distinction from Aristotle. Galileo defines the former as quantitative entity while defining the latter as a qualitative concept. He describes the primary qualities as purely mathematical notions, such as the size, shape, position, and motion of an object. Contrarily, he differentiates the secondary qualities with the properties of colors, tastes, sounds, smells, and other tactile characteristics. Furthermore, this distinction suggests that only the primary qualities occur naturally, while the secondary qualities are mere perceptions. Particularly, the “corpuscular and mechanical philosophers” attempted to portray a “plausible account” of substances, like their “coldness, sweetness, color, flexibility,” etc. (Shapin 52). This implies that these philosophers viewed human perception just as an awareness of the existence of a particular primary quality, not reality itself. On the other hand, Aristotle’s explanations were based on experience and observation—which were strictly qualitative. Altogether, the mechanical philosophers attempted to eradicate perception and only focus on the true reality of an occurrence.

Along with the primary and secondary qualities, the controversial issue of occults further attempted to complicate the question of perception and reality. One of the major differences between these two philosophies revolved around Aristotle's idea of a final cause. Since everything in nature can be reduced to matter and motion, the Aristotelian idea of a final cause did not necessarily exist in the eyes of these mechanical philosophers. Occult and magic, traditionally utilized to interpret inexplicable events, did not factor into their considerations. For example, although Descartes believed in God, he argued, that even though an animal body is "made by the hands of God" and is far superior in design "than any than that can be devised by man," it is still "just a machine"(Descartes 22). He rejected the "very notion of miracles" and thus, "there were no final causes in [his] world" (Westfall 226). Eliminating miracles and final causes in explanations was a divergence from the Aristotelian world. The mechanical philosophers consistently proposed "naturalistic explanations of presumed miracles," and since their philosophy was based on mechanical principles, these naturalistic explanations were methodically executed (Westfall 226). As a whole, the focus on matter and motion granted these mechanical philosophers the evidence to support mechanical philosophy over the occult traditions.

In order to produce evidence needed to displace Aristotelian philosophy, the mechanical philosophers utilized mathematics. Whereas the idea of matter and indivisibility of corpuscles rekindled the ideas of the ancient atomists, the mathematization of nature resurrected the Pythagorean theology. Descartes exemplified this notion by claiming that his method of searching for the truth based on following a "correct order," "enumerate[ing] exactly all the relevant factors," and adopting the "rules of arithmetic" (Descartes 10). In addition to mathematics, a scientific methodology developed, one that would attempt to answer questions based on curiosity. These would include “crucial experiments,” logical reasoning, and precise proofs (Descartes 26). He claimed that “only the mathematicians have been able to find any demonstrations—that is to say, certain and evident reasonings” (Descartes 9). Although Aristotle based his claims on observations and possessed some numerical evidence, it was not as substantial as the mechanical philosophers. Until this period of time, mathematics was “regarded as epistemologically inferior to natural philosophy” since it was viewed as a “practical endeavor” rather than as a pure science (Bowler and Morus 40). The Scientific Revolution elevated the status of mathematics, which in turn, was utilized to obtain crucial evidence for both scientific and philosophical theories. Descartes concluded that his acceptance of a certain truth would be established “because reason convinced” him rather than “because it ha[d] already been said by someone else” (Descartes 30). The template of the combination of mathematics and scientific experimentation was widely followed by the mechanical philosophers. For instance, Boyle conducted the prominent air-pump experiment, Galileo directed the famous experiment on the Leaning Tower of Pisa to disprove Aristotle, and Newton established his Laws on Motion and the Law of Universal Gravitation based on experimentation and mathematical results. Overall, the mathematization of nature and the development of an established scientific method in order to develop conclusions exemplified a tangible shift that had occurred from the time of Aristotle to the time of the mechanical philosophers.

In addition to the mathematization of nature, contributions from Copernicus, Galileo, and Johannes Kepler completely revolutionized astronomy and cosmology, which signaled a shift from Aristotelianism. Not only were the mechanical principles applicable to elements of daily life, they were also relevant to “large-scale phenomena like the movements of the planets” (Bowler and Morus 35). Copernicus proposed the idea of a heliocentric universe, and Galileo endorsed this view. Although it was only an alteration in the astronomical model, Copernicanism generated social turmoil because of its implications. Replacing the geocentric model of the universe would replace humans as the moral leaders of this universe. Galileo's insistence of adopting Copernicanism was viewed as an attack at anthropomorphism and the idea that humans are placed in the center of the universe. Apart from the placement of Earth, Kepler's Laws of Planetary Motions replaced an established old school of thought. Kepler's model replaced the orbits of the planets from being epicyclic to being elliptical. Kepler's models show that the mechanical philosophers stressed that "best way of understanding the cosmos was to regard it as a huge machine" (Bowler and Morus 34). They asserted that "the physics appropriate to understanding machines" were the same needed for "understanding celestial motions" (Shapin 32). This ideology extended the scope of the mechanical philosophy from infinitesimal particles of matter to the ceaseless bounds of the cosmos. Altogether, the modifications of various astronomical models spread the influence of mechanical philosophy and diminished the prominence of the Aristotelian cosmology.

All in all, the influence of the mechanical philosophy especially in astronomical cosmology, mathematical reasonings, determination of reality over perception, focus on matter and motion, and the mechanization of nature thoroughly contrasted with the Aristotelian principles. The mechanical philosophy's emphasis on reductionism, determinism, and materialism was a stark distinction from Aristotle's ideas. While the Aristotelian philosophy centered the world on humans and portrayed causes through mere observations, the mechanical philosophers refuted them by accurate mechanical and experimental models. The influence of these philosophers transformed society's obsolete way of thinking to a more modern one, both in philosophical and scientific point of view. Altogether, the approach of the mechanical philosophers as well as their contributions to science and mathematics, helped displace the ideologies of the western world from an Aristotelian school of thought to the ideologies that have become the foundations of modern philosophy.

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