WHAT THE MIDDLE AGES INHERITED FROM ARISTOTLE

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The following selection comes from chapter 4 of Grant, The Foundations of Modern Science in the Middle Ages *(New York: Cambridge University Press, 1996).*

Aristotle's natural books formed the basis of natural philosophy in the universities, and the way in which medieval scholars understood the structure and operation of the cosmos must be sought in those books. By his use of assumptions, demonstrated principles, and seemingly self-evident principles, Aristotle imposed a strong sense of order and coherence on an otherwise bewildering world. Aristotle's medieval disciples, who formed the class of natural philosophers during the late Middle Ages, would eventually extend Aristotle's principles to activities and problems beyond anything that the philosopher himself had considered.

Aristotle was convinced that the world he sought to understand was eternal, without beginning or end. He regarded the eternity of the world as far less problematic than any assumption of a cosmic beginning that also implied a future end to the world. It was better to postulate eternity than be forced into an explanation that required an infinite regress of causal beginnings. The idea that matter could have a beginning seemed impossible to the ancient Greeks, for if one were to arrive at some alleged pristine matter, it would inevitably lead to the question of what caused it, and so on. Without a beginning, however, the world could not have been created, and thus Aristotle's ideas about the eternity of the world set him in opposition to the theologians of the great monotheistic religions of Judaism, Christianity, and Islam. Of all the issues that involved natural philosophy and theology during the thirteenth century in Western Europe, theologians regarded the eternity of the world as the most difficult and threatening for the faith.

Still, if Aristotle's world was eternal and therefore suspect, his insistence on its uniqueness placed him squarely in agreement with the sacred scriptures of the three great religions. He regarded our world as unique, a large finite sphere beyond which nothing could exist. All existent matter is contained in our world, with none left over. Without body, "neither place, nor void, nor time" could exist beyond the world, because the definitions of "place," ''void," and "time" all depended on the existence of body. For Aristotle the proper place of a body was always the innermost surface of another immediately surrounding body that was in direct contact with the contained body. Thus a place is defined as something in which body must be present. Without the existence of a body beyond our world, no place could exist. Similarly, a void is something in which the existence of a body is possible, though not actual. Therefore, if no body is possible, no vacuum is possible. Finally, time is the measure of motion. Without body there can be no motion and, therefore, no time. Aristotle concluded that all existence lay within our cosmos, and nothing beyond. The "nothing" in this sense is not to be construed as a vacuum, but is best characterized as a total privation of being.

Perhaps the most momentous decision that Aristotle made about the eternal, physical world was to divide it into two radically different parts, the terrestrial, which extended from the center of the earth to the lunar sphere, and the celestial, which embraced everything from the moon to the fixed stars. In the terrestrial region, observation and experience made it obvious that change was incessant, whereas in the celestial region change was virtually nonexistent. Astronomical observations inherited from the past convinced Aristotle that no changes had ever been detected in the heavens (*De caelo* 1.3.270b.l3-17), from which he inferred that changes did not — and could not — occur there. To understand Aristotle's world better, it is advantageous to describe first the terrestrial region of change, which, in turn, will make the unchanging properties and attributes of the celestial region more comprehensible.

The Terrestrial Region: Realm of Incessant Change

Much of Aristotle's natural philosophy is an attempt to identify and explicate the principles of change in the terrestrial region, principles that shaped medieval interpretations of the processes that make the world what it is. Although we live in a world that had no beginning, Aristotle nonetheless explains how the development of matter is to be imagined and how it is differentiated into four basic elements — earth, water, air, and fire — that form the building blocks of all material bodies in the terrestrial region. The underlying basis of all material bodies is prime matter, which, although real, has no independent existence. Aristotle simply infers its reality because it was essential to assume the existence of some kind of substratum in which qualities and forms could inhere and produce sensible matter. Prime matter has no

properties of its own, but is always associated with qualities that inhere in it and define it.

Which properties or qualities would raise prime matter to a higher existent level, say to the level of an element? After eliminating a number of possibilities, Aristotle argues that two pairs of contrary, or opposite, qualities could achieve this effect: hot and cold, and dry and moist. Because nothing could be simultaneously hot and cold, or dry and moist, no single pair of opposite qualities could inhere in prime matter at the same time. Non-opposite combinations, however, are possible and can produce elements. If the qualities coldness and dryness inhered in prime matter, they would produce the element earth; coldness and wetness would produce water; hotness and wetness air; and hotness and dryness fire. Thus were the four elements derived. The perceptible bodies of the terrestrial region were, however, not pure elements, but mixtures, or compounds, of two or more of them, usually called “mixed” bodies in the Middle Ages.

In Aristotle’s natural philosophy, or physics, every body is a composite of matter and form, where the matter serves as a substratum in which the form inheres. The form of a thing, or a body, is its essential defining characteristics, the properties that make it what it is. Nature in the terrestrial realm is nothing more than a collective term for the totality of existent bodies, each comprised of matter and form. Every such body belongs to its own species and possesses the properties and characteristics — that is, the form — of its species. If unimpeded, it will act in conformity with those properties. Aristotle thus attributed to the bodies of the world a power to act in accordance with their natural capabilities. In this way, he allowed for secondary causation, where bodies were capable of acting on other bodies, that is, able to cause effects in other bodies. Aristotle believed that each effect was produced by four causes acting simultaneously, namely a material cause, or the thing out of which something is made; a formal cause, or the basic structure to be imposed on something; an efficient cause, or the agent of an action; and the final cause, or the purpose for which the action is undertaken. The causes that produce a stone not only make it heavy, but, if the stone is otherwise unimpeded, that heaviness confers upon it the capacity to fall naturally toward the center of the earth with a rectilinear motion. Similarly, the agents that produce fire confer lightness upon it and therefore the capability of rising naturally upward, whenever it is unhindered.

Aristotle was also concerned about the kinds of changes that the four causes could produce, distinguishing four kinds: (1) substantial change, where one form supplants another in the underlying matter, as when fire reduces a log to ash; (2) qualitative change, as when the color of a leaf is altered from green to brown in the same underlying matter; (3) change of quantity, as when a body grows or diminishes while otherwise retaining its identity; and, finally, (4) change of place, when a body suffers change as it moves from one place to another.

Of these four types of change, only the first and fourth require explanation. Substantial change is the most basic form of change, involving generation and corruption. For Aristotle every substantial change implied that something had come into existence from the passing away of something else. This coming-to-be and passing-away of things was the basis of all change in the terrestrial region. It occurred in all substances composed of matter and form, which in the terrestrial region included all things. Forms, or qualities, were potentially replaceable by other forms that were their contraries. When this occurred, one substance was changed into another. For example, fire, which possesses the primary qualities of hotness and dryness, is changed into earth, which possesses the primary qualities of dryness and coldness, when the hotness in fire is replaced by coldness, its contrary quality, or form. While one form is actualized in matter, its contrary is said to be in privation but potentially capable of replacing it. Eventually, each potential form or quality must actually become what it is capable of becoming; otherwise a form would remain unactualized, and nature would have produced it in vain. While one of a pair of contrary forms is actualized in matter, its contrary is absent and in privation, because two contrary forms cannot exist simultaneously in the same body. Virtually all change, that is, generation and corruption, involves the possession of one, and the exclusion of another, of a pair of contrary forms or qualities.

The last of the four changes, change of place, represents what we ordinarily think of as motion, the removal of a body from one location to another. Aristotle’s doctrine of place may be viewed in two ways. In its broadest signification, it concerns the structure of the sublunar world; and in the narrowest and most restrictive sense, it involves the specific place of a single body. The broad sense of place is really the doctrine of natural place, in which Aristotle conceived of the part of the world below the moon as a structured region divided into four concentric areas, each the natural place of an element, toward which that element would naturally move if unimpeded. Thus the outermost concentric ring, located just below the concave surface of the lunar

sphere, is the natural place of fire; the next concentric ring is the place of air, toward which air rises if in the regions below, or toward which it would fall if, for some reason, it was located in the region of fire; below air is the ring of water; and below that the sphere of our earth, the center of which coincides with the geometric center of the universe.

The earth’s sphericity was a basic truth of Aristotle’s system of the world. As observational evidence of its sphericity, Aristotle pointed to the curved lines of the Moon’s surface during a lunar eclipse, inferring rightly that these were cast by the shadow of a spherical earth interposed between the Sun and the Moon. He also noted that as one changed position on the earth’s surface, different stellar configurations came into view, indicating that the earth possessed a spherical surface. The sphericity of the earth seemed further confirmed by the way bodies were observed to fall to the earth’s surface in nonparallel lines that met at its center. If all earthy bodies fell in this manner, they would cluster around the center of the world and form naturally into a sphere. So reasonable were Aristotle’s arguments that a spherical earth was readily accepted. […]

The Celestial Region: Incorruptible and Changeless

The part of the world that Aristotle envisioned beyond the convex surface of the sphere of fire was radically different from the terrestrial part just described. Aristotle regarded the celestial region as so incomparably superior to the terrestrial that he assigned to it properties that emphasized these profound differences. If incessant change was basic to the terrestrial region, then lack of change had to characterize the celestial region. This conviction was reinforced for Aristotle by his belief that human records revealed no changes in the heavens. Because the four elements of the sublunar region were involved in ceaseless change, they were obviously unsuitable for the changeless heavens. In his *On the Heavens* (bk. 1, chs. 2 and 3), Aristotle contrasted the natural rectilinear motion of the four sublunar elements (earth, water, air, and fire) with the observed regular, and seemingly natural, circular motion of the planets and fixed stars in the celestial region. The contrast between the straight line and the circle, the former finite and incomplete, the latter closed and complete m itself, convinced Aristotle, if he needed convincing, that the circular figure was necessarily and naturally prior to the rectilinear figure. Because the four simple elemental bodies moved with natural rectilinear (upward and downward) motion, Aristotle concluded that the observed circular motion of the celestial bodies must necessarily be associated with a different kind of simple, elemental body: a fifth element, or ether.

As if to emphasize the special importance of the ether, Aristotle often called it the “first body.” Its primary properties were almost the opposite of those of the terrestrial elements. Where terrestrial elements moved naturally with rectilinear motion, the ether moved naturally with circular motion, which was superior because the circle was complete in itself, whereas the straight line was not. Where the four elements and the bodies compounded of them were in a continual state of flux, the celestial ether suffered no substantial, qualitative, or quantitative changes. Substantial change was impossible because Aristotle assumed that the pairs of opposite, or contrary, qualities, such as hotness and coldness, wetness and dryness, rare and dense, which were basic forces for change in the terrestrial region, were absent from the heavens and therefore played no role there. Aristotle’s rejection of contrary qualities in the heavens led him to deny the existence there of the contrary qualities lightness and heaviness, from which he concluded that the celestial ether could be neither light nor heavy. Lightness and heaviness in the terrestrial region were associated with upward and downward rectilinear motions: heavy bodies approached the earth when they moved naturally downward, and light bodies receded from the earth when they moved naturally upward. In the absence of heaviness and lightness in the heavenly region, Aristotle inferred that rectilinear motions could not occur there. Thus not only was it observationally evident that the celestial motions were circular, but, from the very properties of the ether itself, it was apparent to Aristotle that rectilinear motions were impossible in the celestial region.

Because planets and stars are observed to move around the sky, Aristotle inferred that change of position was the only kind of change possible m the heavens. Celestial bodies continually change their positions by moving around the sky with effortless, uniform, circular motion. This uniform, circular motion is a natural motion, just as rectilinear up-and-down motions are natural. But where up and down were contrary terrestrial motions, circular motion had no contrary. Aristotle concluded that circular motion, which lacked a contrary motion, was natural to bodies composed of celestial ether, which lacked contrary qualities. In the absence of all contraries, change as it was observed in the terrestrial region could not occur in the ethereal heavens. Celestial bodies had to move eternally around the heavens with natural, uniform, circular motion. Although they changed positions, the absence of contraries prevented variations in their distances.

Aristotle thus assumed that celestial bodies neither approached the earth, nor receded from it.

Aristotle associated change with matter, but he denied change in the heavens. Did it follow then that the heavens lacked matter and that the celestial ether, whatever else it might be, was not to be thought of as matter? On this important issue, Aristotle’s remarks are inconclusive, and medieval natural philosophers were left to ponder his meaning. Both interpretations — that matter exists and does not exist in the heavens — received support.

Whether or not it was to be construed as matter, the celestial ether posed other problems. Because it was a perfect substance extending from the moon to the fixed stars, Aristotle seems to have thought of the ether as homogeneous, with all its parts identical. A glance at the heavens should have dispelled such a notion. At the very least, the celestial region consisted of visible bodies surrounded by empty portions of sky, a configuration that hardly suggests homogeneity. If celestial bodies and empty sky were both composed of the same ether, why did they differ? Why were planets and stars visible, and the rest of the sky effectively invisible? If the planets were made of the same ether, why did they seem to differ from one another? Why did their properties vary? To these questions, Aristotle supplied no answers, perhaps because the questions never occurred to him. When such questions occurred to his Greek, Arabic, and Latin commentators, they had to devise their own responses, a common fate for those who spent much of their lives seeking the meanings of Aristotle’s texts. […]