Feb. 03, 2016

HSS102

Aristotle: Cosmology and Method

Aristotle was perhaps the MOST influential natural philosopher of antiquity. He recaptured important aspects of the naturalism of pre-Socratic philosophers which were in the danger of getting lost after Plato. He brought knowledge back to earth.

He offered sophisticated answers to all the questions that had been puzzling the pre-Socratics and Plato like: nature of the fundamental stuff, the proper means of knowing it, the problem of change and causation, the basic structure of the cosmos, the nature of God and its relation to material things.

After the rise of Christianity, Aristotle’s ideas were lost. They were re-discovered and revised by Islamic philosophers and scientists and re-introduced to medieval Europe. Gradually, Aristotle’s worldview came to dominate the Christian church and became the dominant paradigm of science around 1200 AD. The Scientific Revolution that occurred from 15th century onward, had to struggle against and overthrow the Aristotelian worldview.

# Life and works:

Aristotle was born in 384 BCE in a northern Greek town into a privileged family. His father was the personal doctor of the king of Macedonia, Amyntas II who was the grandfather of Alexander the Great. When he was 17 yrs of age, he was sent to Athens to study with Plato in the Academy where he stayed for 20 years. After Plato’s death, he left the Academy and travelled around. He ended up becoming the personal tutor of the young Alexander the Great. After Alexander went off on his conquests, Aristotle returned to Athens and set up a school called the Lyceum, which was really a garden where students and scholars met. Later in his life, he was forced by political circumstances to leave Athens and he died one year later, in 322 bce.

ARISTOTLE AND PLATO:

Plato and Aristotle have been described as the “twin stars” that complement each other. As Arthur Koestler put it in his famous book, *The Sleepwalkers*, :

They were twin-stars, born to complement each other; Plato the mystic, Aristotle the logician; Plato the belittler of natural science, A the observer of dolphins and whales; Plato the spinner of allegorical yarns, A. the dialectician and casuist; Plato, vague and ambiguous, Aristotle precise and pedantic. P. 55

Bertrand Russell has called A’s philosophy as “plato diluted with a bit of common-sense. “

Main differences:

1. One major difference between the two was that Aristotle loved facts and looked for definite knowledge. Plato on the other hand, had no respect for sensory knowledge of the material world – all that was a mere shadow-play for him.

BIOLOGY – especially the study of animals – was A’s first love. About a fifth of his writings that have survived describe some 540 zoological species. He described in great details the digestive system of ruminants, the habits of ocutpouses, squids, bees…. He is said to have observed the progress of chicken embryos by breaking one egg every day. He is said to have dissected eyes and stomachs of animals. His writings had titles like” on the Parts of Animals”, “One the Movement of Animals,” “on the Origin of Animals.”

Ironically, even though most of his scientific work was in zoology, his historical influence lies in his ideas about the universe – the earth, the sun and the planets. His teachings on logic and metaphysics – the basic constituents of nature – also played an important role in history of science. Two of his books titled “Physics” and “on the Heavens,” continued to be influential until the time of Galileo.

Aristotle was an extremely productive scholar. He is credited with more than 150 treatises, approximately 30 of which have come down through the centuries. These 30 alone take up about a foot of bookshelf. He wrote on many other subjects besides science. His works on ethics, politics and art are still read with great interest.

1. Difference in style: Plato was a story-teller, while A wrote as a modern-day professor. As we do today, before presenting his own views, he used to do a literature review of all that others had said about a subject before him. In fact, that is how we have come to know of what Thales and other pre-Socratics thought.
2. Philosophical difference (and this is the most important difference): Aristotle rejected Plato’s theory of Forms or Ideas.

* Recall that his guru, Plato, taught that:
  + - Earthly objects – objects we see with our eyes – are pale shadows of ideal forms. The ideal forms come first before the object and the shadows… The idea of a chicken came first before a chicken and the egg!!
    - The ideal forms can exist separate from the object. They exist in the mind of the creator/Deimurge
    - The ideal forms cannot be known through sensory experiences, but by philosophical reflection and mystical practices. (Recall the allegory of the cave).
    - True knowledge consists of knowledge of the forms.
* Aristotle rejects his master’s teachings in two essential aspects:
  + - He rejected that sensible objects (I,e, objects that we can grasp through our senses) are rough copies of the forms. He argued that they are real and exist independently.
    - He rejected the Platonic idea that ideal forms can exist apart from the body itself. He thought it was silly of Plato to make Ideas the essence of things and still put them outside of the thing itself. The essence of things, he said, must be IN the thing, and not outside.

Thus, for A, there is no perfect form of a dog, or a table, or any X for example, existing independently and getting replicated in individual X**. For Aristotle there were only individual dogs, or tables etc. and nothing else.** These dogs certainly shared a set of properties that made them dogs, but these properties, or forms, belong to individual dogs themselves. What Plato called Ideas and Forms was ONLY THE NAME WE GIVE to the idea AFTER we have seen a number of objects… The Form belongs to the body itself and the two cannot be separated.

* This means that true knowledge is knowledge of concrete objects. That means that quest for knowledge has to be directed at the material world of individuals, of nature, of change – a world encountered by senses.

Plato wanted us to leave the dark cave for the sunlight of absolute truth of ideal forms that can only be seen by some. Aristotle found the cave interesting and rather than run away from the darkness, he wanted to switch on the light in the cave itself so that we can see the world of here and now through our eyes and other senses.

1. Another important difference was A’s focus on CHANGE, motion, development, growth. For Plato, these were non-issues: it was enough for him to say that white objects exist, for e.g., because they share the idea of whiteness. For A, physics was the study of change.

FOUR BASIC COCEPTS of Aristotle:

1. NATURE OF THINGS/ESSENTIALISM

Natural objects were viewed as having essential natures, and these essential natures was the reason why they behave as they do. All objects are made of matter (SUBSTANCE) arranged in specific ways (FORM) which makes some abilities, tendencies, potentials and purposes inherent in the object.

1. CHANGE:

The basic question Aristotle asked was: why things change?

Recall that his guru, Plato, had limited change to the imperfect material world : his ideal world of forms was eternal and did not change.

Aristotle was a biologist and was a keen observer of life-cycle of animals and plants: he is reported to have broken an egg every day to follow the development of a chicken embryo. So he took the idea of change very seriously.

**He said things changed in order to fulfill their potential which was inherent in their essential natures. Change was nothing but the potentiality becoming actuality.**

He used the example of an acorn that grows into an oak tree. An acorn is potentially an oak. When it changes into an oak, it is fulfilling its potential. This potentiality to become an oak was “immanent” or inherent in the oak due to form in which its substance was organized: the form of any strucuture imprinted upon it a certain dynamic that expressed itself as change (growth, maturity and death etc.)

Like the acorn, everything has an essential nature which it seeks to fulfill. ALL CHANGE AND MOTION CAN BE TRACED TO THE NATURE OF THINGS.

1. CAUSES OF THINGS

According to Aristotle there are four main things one must ask of anything:

1. **Material cause**: the matter our of which it is made. E.g., the material cause of a house is bricks, wood, steel etc. (Rain: water) The materialists were exclusively concerned with this cause.
2. **Efficient cause**: who made it? the agency behind an object. The efficient cause of a house is the builder, the bricklayer. (Rain: the cooling of the moisture/condensation
3. **Formal cause**: the structure or design, the form. e.g., the formal cause of a house is the architecture (rain: the form or the nature of water is to fall down)
4. **The final cause:** what goal, end or purpose does it serve? The final cause – the purpose -- of a house is to provide shelter. (rain: so that plants can grow; wheras we will say that plants grow because they find moisture, )

FINAL CAUSE LEADS TO what is called **TELEOLOGICAL THINKING**, or TELEOLOGY: the idea that natural objects – including inanimate ones -- have goals and purposes, and that they move or develop in the way they do because they are seeking to fulfill a purpose is what is called teleological. TELEOLOGY OR PURPOSE WAS AN ESSENTIAL FEATURE OF NATURE; IT WAS BUILT INTO IT. : if a stone falls to the earth, it is because it is predominantly made of earth elements and it is the nature of Earth to seek its home, or the place where it belongs.

This did not imply that ordinary stones KNEW or STRIVED to get to the earth. But whether THEY knew it or not, OUR explanation cannot be complete till WE explain why they are falling to the earth.

This is closely related to the first idea discussed above, namely, essentialism. The purposes are built into the essential natures of things. Teleology and essentialism are the two sides of the same coin.

Aristotle on motion

Two fundamental principles

1. All movement requires a mover – nothing moves unless there is a mover in direct contact with the object.
2. There are two kinds of motions:
3. Natural motion : when the object moves toward its natural place; the “mover” is internal to the object, that is to say simply the body has a natural tendency to move toward its natural place.

When an object reaches its natural place, it stops.

What happens to mixed bodies, which have elements of water and earth, for e.g.? Its motion will depend upon whichever element is predominant

1. Violent motion, or unnatural motion: when a body is made to defy its natural tendency ; e.g, when a ball is thrown upward;

Violent motion always requires external force which forces a body to violate (go against) its natural tendency.

Violent motion stops when the contact between the mover and the body is stopped.

But what about projectiles? Javelin? The air pushes it and then it falls

“Law of motion”

In the terrestrial realm, the quickness of motion depends upon

1. The force
2. Resistance

Even though he did not state it in mathematical terms, A proposed the following “law” in two of his important books, On the Heavens and Physics :

**When two bodies of differing weights fall, the times required to cover a given distance will be inversely proportional to their weights. (if one ball is twice as heavy, it will need half the time)**

**When two bodies of same weight fall in different media, the body will mover more slowly in a denser medium.**

**V is proportional to F and inversely proportional to R.**

# Aristotle’s Great Deduction:

1. Aristotle’ four basic elements: Aristotle accepted the conventional wisdom of Empedocles, Hippocratic doctors and other philosophers of that era and assumed that all substances to be compounds of four *elements*: earth, water, air and fire, and each of these to be a combination of two of four *opposites*, hot and cold, and wet and dry. (Actually, the words he used for wet and dry also have the connotation of softness and hardness).

Fire Hot air

Dry wet

Earth Cold water

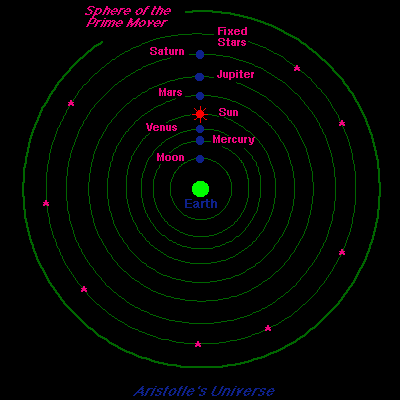
1. The four elements have essential natures which endow them with goals:

* The element earth has a natural tendency to fall move toward the center of the universe. Or, to put it differently, the element earth has a natural tendency to fulfill a certain goal, namely, of being at the center of the universe
* The element water also has a natural tendency to move toward the center of the universe, but its tendency is not as strong as that of earth.
* The element air has a natural tendency to move away from the earth but below the element fire
* The element fire has a natural tendency to move away form the earth.

From these fairly common-sense observations, Aristotle deduced the arrangement of the entire universe. He argued as follows:

* Since the natural tendency of earth is to move to the center of the universe, it MUST arrange itself symmetrically around that point – therefore earth is a sphere in the center of the universe. He added the observational data that the shadow cast by earth on a lunar eclipse is a circular NO FLAT EARTH.
* Because water is lighter, it will collect in a concentric circle just outside the earth
* Air and fire naturally rise up, fire more than the air. Thus there is a concentric circle of air around water, with fire at the outer edges. (see the four concentric circles in the ppt)
* The moon was attached to the ring of fire, and beyond the moon he placed the planets in concentric circles around the earth
* Because in the heavens things move in circles while they move in straight lines on the earth, A inferred that that heavens are made of different stuff. Aristotle called this heavenly stuff “QUINTESSENCE” (literally , the fifth element) or ether.
* Beyond the outer edge of the ring of fire where he placed the moon, the immobile earth is supposed to be surrounded by NINE concentric, transparent spheres, enclosing each other like the skins of an onion. The innermost skin is the sphere of the moon, the outermost are the sphere of the fixed stars, and beyond that the sphere of the PRIME MOVER or the UNMOVED MOVER who keeps the whole machinery working.
* These spheres were supposed to be made of “quintessence” (i.e., fifth essence, apart from the four elements of earth, water, fire and air). The heavenly bodies – planets and stars are physically attached to these spheres and are carried around the earth as the spheres themselves rotate around the stationary earth in perfect circles forever and ever without stopping.

This is how A’s universe looked like (see picture below and also on PPt)



ARISTOTLE’s COSMOLOGY

1. A. considered the universe as a great sphere divided into two by a spherical shell to which the moon is attached.

* Above the moon is the **celestial region**
* Between the moon and the earth Is the **terrestrial region**, also called the sub-lunnar region
* Reconciling idealists and materialists – handing the celestial realm to unchanging forms, the terrestrial realm to materialists.

1. The celestial region is the region of eternally unchanging cycles of stars.

* This is based upon observation – fixed stars keep rotating around the pole star year after year.
* Circular motion as the perfect motion : it is endless. It has no beginning and no end. It can go on forever. It is motion without change.
* Aristotle saw the celestial region completely filled with ether, without any void and divided into concentric spherical shells on which planets are attached.

1. The sub-lunar or terrestrial space is the region of change. Here things are born, they grow, decay and die. In this region there is change and all sort of stuff.

Aristotle’s model of the universe:

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But this model is only a rough approximation. In reality, Aristotle assigns 54 spheres to take care of all the planets and the fixed stars. Each of the nine spheres is a nest of spheres-within-spheres.

Why did he need 55 spheres to move 9 planets? What is going on here ???

The answer to this question will lead us to the PROBLEM OF PLANETARY MOTION that was befuddling astronomers of this era and how they tried to SAVE THE APPEARANCES WITHIN THE DOGMA OF CIRCULA MOTION: