# Plato and Aristotle

This topic is about is about the Ancient Greek philosophers Plato and Aristotle and their influence on the direction of natural philosophy, science and mathematics. Plato and Aristotle set the stage for the next 2,000 years of intellectual development in both the Latin and Islamic West. Though they agree on many aspects of natural philosophy it is where they disagree that will be our focus. Specifically, they disagree about the metaphysical relationship between mathematics (and other abstract forms) and the natural world and also the epistemological priority of mathematics (and other abstract forms) and individual substances in the world. Put simply, Plato thought that what is most real and best known is abstract mathematical forms are whereas Aristotle thought that individual objects are most real and mathematical forms are abstractions from those individuals.

# Plato

We will begin with Plato’s natural philosophy and especially those aspects of his natural philosophy which were Pythagorean. We will focus on Plato’s theory of the **Forms**, his **geometric atomism of platonic solids**, and his account of the **celestial sphere**. Unlike the Pre-Socratic Philosophers, Plato’s philosophy is not primarily about the natural world. However Platonic Pythagoreanism as expressed primarily in the *Timaeus* was to become one of the primary influences on natural philosophy throughout the middle-ages and plays a significant role in the mathematical view of the natural world as developed by Copernicus, Kepler Galileo, and Newton and persists to this day. For example, Roger Penrose is outspoken about his commitment to Platonic Pythagoreanism.

Pythagoras is a figure for which it is difficult to separate fact from myth. Pythagoras formed long lasting schools/religious communities. Students of these schools and people influenced by these schools tended to attribute their own discoveries and achievements to their founder. Pythagoras lived around the time of Thales (roughly 500 years before Christ). He learned geometry from the Egyptians and brought it back to the Greeks. The Pythagoreans invented the concept of abstract mathematics. They are most famous for the theorem that for any right triangle, the square of the length of the hypotenuse is equal to the sum of the squares of the lengths of adjacent sides, i.e. C2 = A2 + B2. They also discovered that mathematics is the difference between music and noise. The Pythagoreans showed the mathematical relations between the length of a string and its tone: i.e. every doubling of the length of a string raises the tone exactly by an octave and that the notes within the octave are also based on exact mathematical proportions. The Pythagoreans also held far more mystical theories about numbers. For example, they maintained that the number 4 somehow represented justice and that the motion of the celestial spheres produces a kind of cosmic harmony. This mysticism may have been encouraged by their discovery that the length of the diagonal of a unit square cannot be represented by a ratio of whole numbers and that the mathematical proportions of notes is not consistent between different octaves. In any event, The Pythagoreans held the metaphysical view that “everything is number.” It’s hard to know what they meant by this mathematical atomism but at a minimum they maintained that the order underlying all natural phenomena is mathematical in the sense that it should be described using universal mathematics.

Plato was a student of Socrates. Socrates was executed by the city-state of Athens in 399 BC. He was executed for questioning the Greek polytheistic religion. For example in the dialogue *The Euthyphro* Socrates questions whether the commands of the gods can provide an adequate justification of the laws and ethical principles. Socrates is also accused of being “a curious evil-doer who investigates things under the earth and in the heavens.” One specific charge mentioned in *The Apology* was that Socrates “claimed that the sun is a stone.” Why might it be problematic to claim that the sun is a stone?

The trial and execution of Socrates is perhaps the first conflict between religion and natural philosophy. However, we have to be very careful about painting too simple of a picture of the relation between religion and natural philosophy as a conflict. The relationship is complex and more often then not, religion and natural philosophy have worked hand in hand and supported each other. When there is conflict, it is usually as much political as religious. This certainly is true of the two most famous historical conflicts between religion and natural philosophy: that of Socrates and Galileo. The former is directly related to Socrates’ affiliation with the Thirty Tyrants installed after the Peloponnesian War and Galileo’s conflict with the Catholic Church has as much to do with the politics of the Reformation as it is related to a simple science-religion conflict.

After Socrates’ execution, Plato traveled in Italy where he came into contact with the Pythagoreans and became deeply influenced by their doctrines. One of the most pervasive influences is in Plato’s epistemology or theory of leaning and knowledge. This epistemology is explained in [Plato’s Allegory of the Cave](https://www.youtube.com/watch?v=UQfRdl3GTw4), which appears in book 7 of *The Republic*. The Allegory of the Cave is a parable about the human condition and what education can do for the human soul.  We are the prisoners in the cave so long as we rely only on sense experience of particular material objects for knowledge of reality.  Objects on earth as perceived through the bodily senses are, like the shadows in the cave, merely imperfect copies of what is most real.  It is only through mathematics and philosophy that we can leave the cave and encounter reality in its pure Form.  Thus while we can perceive imperfect copies of various (say) horses using our senses, it is only through the intellect that we can know the perfect eternal reality of the Form Horse.  Thus Plato is a dualist in the sense that there exist two separate realms. The imperfect and changing realm of the material world is known though sense experience. The eternal and unchanging realm of the Forms is known through the intellect. The human person is similarly a dualist object divided into a body and a soul. The eternal and unchanging human soul is basically trapped in her physical body. Plato incorporates his doctrine of the Forms in the creation myth he presents in the *Timeaus*.  In that text, Plato maintains that the *kosmos* is created by a divine demiurge craftsman who uses the eternal Forms as a blueprint.  However, the material world is imperfect because matter is inherently incapable of fully instantiating the Forms.  Similarly, the demiurge creates the immaterial human soul himself but assigns the task of creating the human body to a class of lower deities.

The demiurge creates the elements the material world on geometric principles.  The four elements (fire, earth, air, and water) consist in what have come to be called the platonic solids—the only five symmetrical solid figures formed of identically shaped surfaces, hexahedron, the tetrahedron, the octahedron, the icosahedron and the dodecahedron. Change in the world is explained by the fact that these basic elements can combine in various proportions to produce all material objects. Even the elements themselves can be converted into one another when the triangles which make up the polyhedral fall apart and recombine.

According to Plato, the universe itself is spherical with the earth at its center. The entire sphere rotates do to an animating force which he calls a soul. The sun, moon, and all the known planets (Mercury, Venus, Mars, Jupiter, and Saturn) are all perfect spheres which move in perfect circular motions around the earth. He believed that the seasons were caused by the fact that the sun’s motion around the earth was tiled in relation to the equator. He also noticed that the moon and the other planets follow a similar path, which he called the ecliptic. -Note: The Ancient Greeks, Romans, Medievals, and Early Moderns all knew the earth to be spherical. The idea that the Medievals and early moderns thought the earth to be flat (and that one might sail off the edge) is a Nineteenth Century myth, which has been passed down from school teachers to students since then.

I think it is fair to say that the *Timeaus* does not qualify as science and maybe not even as natural philosophy. However, the ideas within it were extremely influential among Christian and Muslim natural philosophers. The ideas outlined above formed the basic conceptual framework within which natural philosophy was to develop. One of the main themes I would like you to learn this semester is that it is common for scientific and mathematical ideas and theories to develop from ideas which today we would identify and patently non-scientific.

So Plato’s *Timeaus* seems to contain ideas and approaches to the natural world that are identical to neither the polytheistic - tradition that came before him nor the monotheistic natural philosophy tradition which was to follow. In class we will discuss the following two questions in your groups:

1. The way in which Plato’s ideas are different from/similar to polytheistic mythopoetical tradition
2. The way in which Plato’s ideas are different from/similar to the monotheisitic natural philosophy tradition. In particular note which ideas would have seemed appealing to monotheistic Christians and Muslims.

# Aristotle

Aristotle became a student in Plato’s Academy when he was just 17. He studied with Plato for the next twenty years. When Aristotle was passed over to head the Academy after Plato’s death in 347 BC, Aristotle founded his own school, the Lyceum. Aristotle would go on to become the dominant intellectual figure for the nearly two thousand years. Aristotle’s natural philosophy would only fall out of favor in the fifteenth century, with a revival of the kind of Platonic Pythagoreanism we studied in the last lesson. Plato, Aristotle, and many of the pre-Socratic philosophers, are depicted in the famous painting by the 16th century master Raphael: The School of Athens. http://en.wikipedia.org/wiki/The\_School\_of\_Athens

This paining is full of symbolism and meaning. Perhaps most obviously, Plato is depicted as pointing upward toward the realm of the eternal unchanging Forms whereas Aristotle has his hands outstretched to the material world. Notice also that Plato is depicted as Leonardo da Vinci, who was a well know Platonic Pythagorean.

Though there are many similarities between the natural philosophies of Aristotle and Plato, there are also many differences. Perhaps the most far-reaching difference is Aristotle’s rejection that the Forms can exist independently of matter. Aristotle completely rejects the idea that the forms exist in an eternal, nonmaterial realm. For Aristotle, everything that exists is an individual substance in nature that has both matter and form. Like Plato, Aristotle believed that humans could know the universal forms. However, unlike Plato, he believed that sense experience of material individuals gives rise the knowledge of the universal categories of nature.

# Aristotle’s Dualism

Although Aristotle rejected the Platonic dualisms of form/matter and of body/soul, he did create a new kind of dualism between sub-lunar and supra-lunar. In this physical dualism, objects below the moon are constantly changing and subject to the laws of physics. All sub-lunar objects are made of the four elements of earth, water, air and fire. They are also constantly changing in their essential and opposite qualities of hot-cold and wet-dry. Aristotle’s system of change is illustrated in the square of opposition of Aristotelian elements. This system was to become the primary conceptual framework for Alchemy. http://web.eecs.utk.edu/~mclennan/BA/RE.html The super-lunary heavens are prefect and unchanging. The celestial objects such as the sun, planets, and stars move at a uniform speed and in circular motion. Unlike object in the sub-lunary realm, objects in the heaven can continue to move without any external force. Heavenly objects are not made of the normal elements of earth, air, water and fire but rather a substance known as quintessence.

# Aristotle’s Four Causes

According to Aristotle, objects (and change) are to be explained in terms of four causes:

1. The formal cause: the form of a thing
2. The material cause: The matter which makes up the thing
3. The efficient cause: the agency that brings about the thing or change
4. The final cause: the purpose for which the thing exists or the change was brought about.

The formal cause answers the question: What is it to be? Or what sort of thing is it? The simplest formal cause can be a shape but it can also be a statue or a dog. The material cause answers the question: what’s it made of? This question can be answers at the level of the substance, the level of the elements or (trivially) at the level of the quality less matter that underlies the elements. The efficient cause is very close to the modern notion of cause. The final cause, which Aristotle says is the most important cause, illustrates Aristotle’s view that the entire universe is teleological or purposeful. Aristotle’s teleological approach to the natural world shows that he did not view the universe as lifeless and inert but rather as purposeful and goal directed. I think it is useful to contrast his view of the universe with the view that emerged from the scientific revolution. The moderns take lifeless matter to be basic and view organisms and life in general to be explained in terms of matter. In other words, the existence of matter is taken as basic and life requires explanation. In contrast, Aristotle appears to take life and living organism as basic and tries to explain matter and the behavior of matter in terms we would only accept, if at all, for biological objects and processes.

We misunderstand Aristotle if we try to understand his theory of causes using our modern notion of causation. The theory is best thought of as a method for understanding the world. The reason that Aristotle’s theory of causes dominated scientific explanation for two thousand years is because it provides a comprehensive method for investigating the world and the objects it contains. If we encounter a new object (say we discover a new organ in an animal or a new mineral) a reasonable way to investigate it is to ask: what is it made of? (material cause) what made it? or how did it come to exist? (efficient cause), and what does it do? or what is its purpose? (formal cause). The method of four causes explains each object in relation to other objects and explains the object’s role in the teleological cosmos.

As the formal and final causes illustrate, Aristotle thinks that every natural object has an internal principle of change that guides them to their final end or goal. For example, an acorn has an internal principle that guides it to become and oak tree. But also, a rock has an internal principle which guides it to fall because its natural place is at the center of the earth. Similarly, water is naturally heavy and as such belongs on the earth, whereas fire and air naturally belong in the lunar sphere which explains why they naturally rise from the earth. Motion itself has two primary principles. First, all motion requires a mover. Bodies are naturally at rest. There are two types of movers: **natural and violent**. Natural motion is explained by the final causes of things whereas violent motions are the result of a force interfering with the natural tendency of the thing. Thus I can throw a rock in the air and thereby violently force it to move upward, but eventually its natural tendency to be at the center of the universe will cause it to descend until it reaches the ground. When an object reaches its natural state, motion stops. Another example, perhaps closer to Aristotle’s primary interest, is the development of an egg into a chicken embryo and finally into a chicken. Artifacts or human contrivances have no internal principle of change but receive their final cause from their efficient cause (humans).

While Aristotle does not distinguish between the organic and inorganic (at least not the way moderns do) he does draw a strong distinction between the natural and the artificial or artifact. An egg, if left in its natural environment will, all by itself or according to its form and final end, develop into a chicken. A rock will fall because of its nature. Natural objects have specific **potentialities** as well as their current **actualities**. Potentialities are defined for each natural object. An egg is potentially a chicken but a rock is not. In contrast, artifacts do not have an internal principle of change and therefore require human interference to bring about that final cause. Finally, humans can use *techne* (technology, know-how) to help natural objects reach their final goal. Let’s say an egg has been removed from its natural place under the hen (violent motion). It is possible for us to use an incubator to help the egg become and embryo and a chick. Aristotle thinks that we can only help natural objects to reach their final end and not change that end. In contrast to the sub-lunar objects, objects in the heavens are made of a quintessence (sixth essence) that is incapable of qualitative change. The only motion they undergo is perfect circular motion.