Dawn of Science

2. The Athens Factor

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The tradition started by Thales was ably continued by the later Greeks, making Athens and Alexandria shine as scientific capitals around the Mediterranean. Prominent among the Athenians were Pythagoras (582–497 BC), Plato (427–347 BC) and Aristotle (384–324 BC) .

Pythagoras, born at Samos, an Aegean Island emigrated to Croton in southern Italy in 529 BC. By that time, the coasts of southern Italy and eastern Sicily had been colonised by the Greeks and had adopted the Greek way of life. Pythagoras founded a school in Croton, thereby extending the philosophic tradition of Thales – prevalent in eastern Greece – to the far west. The members of the school debated mathematics, philosophy and theology in great detail but, unfortunately, maintained a code of secrecy over the entire exercise. This earned the school the disrepute of being a mystery cult of dangerous values and brought it under active persecution even during Pythagoras's lifetime. In fact, Pythagoras had to flee the city and live his last ten years under voluntary exile.

This secrecy over their transactions had prevented later historians from judging the Pythagorean contribution in an objective manner. None of the writings by Pythagoras has survived and his contributions have to be ascertained by references made by later thinkers. The following two contributions definitely deserve to be highlighted.

The first one was the series of experiments that Pythagoras conducted on the production of sound by studying the notes emitted by plucking a stretched string. He realised that sounds pleasant to the human ear are invariably associated with rational steps in the scale of notes. He also related the note to the length of the plucked string. For example, if one string was twice as long as the other, the note it emitted was just one octave lower. These were probably the first sensible systematic experiments conducted in any branch of physics.

Figure 1.

These results led Pythagoreans to think that the entire world can be constructed using simple, rational numbers. (So enamoured were they with this idea that they attributed several mystical properties to natural numbers!) Though such ideas were too simplistic, it opened up the study of numbers – an active branch of modern mathematics. (See *Box* 1.) One can easily imagine their shock when they realised that there existed numbers which were not rational; that is, numbers which could not be expressed

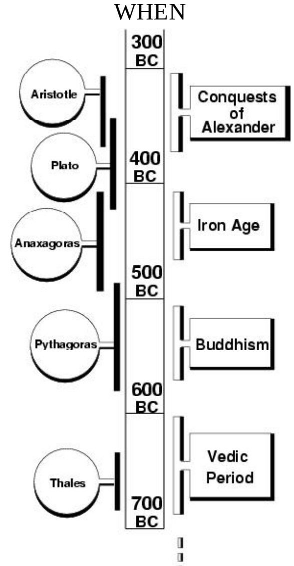
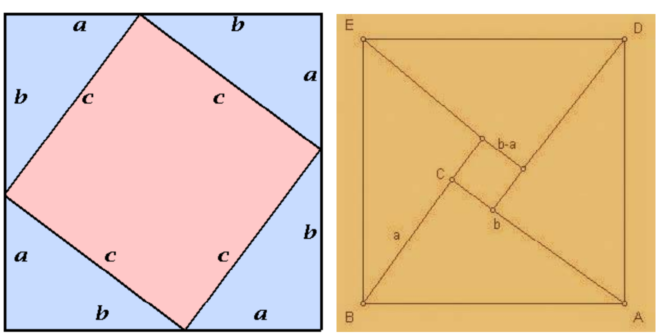


Figure 2.

Box 1. Proving The Pythagoras Theorem

The 'standard' proof of this famous theorem is pretty complicated. But it is possible to see the validity of this result without much ado if suitable figures are drawn. The figure here illustrates a few 'proofs without words' of this theorem. The left one was known to the ancient Chinese; the right one was given by Bhaskara with the comment 'Behold!'.

(a) (b)



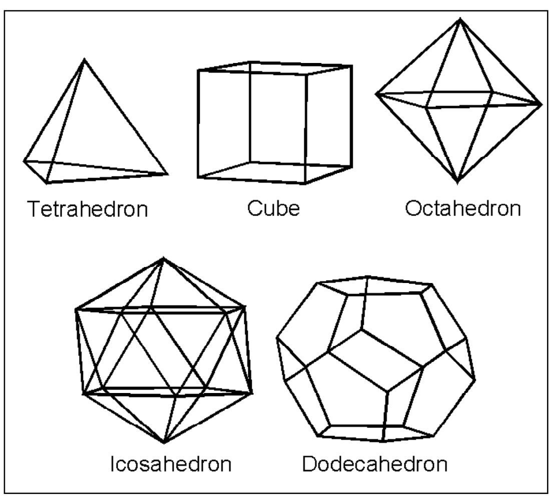
Pythagoras was the first man to introduce the atomistic view of matter.

as the ratio between two natural numbers. If the side of a square is one unit, then the length of the diagonal of the square represents an irrational number. Legend has it that Pythagoreans tried hard to keep the existence of such numbers a secret but the information slipped out – through some unfaithful ones!

Pythagoras was also probably the first who taught that the Earth was spherical and that the orbits of the Sun, the Moon and planets were different from that of stars. He also guessed that the Morning Star (Phosphorus) and the Evening Star (Hesperus) were in fact the same; he named it Aphrodite, which we now call Venus. Pythagorean notions influenced several later thinkers like Anaxagoras (500–428 BC), who taught at Athens for nearly 30 years and tried to put Pythagorean ideas on a more rational basis, and Democritus (470–380 BC). He was the first man to introduce the atomistic view of matter.

The most famous among those who hailed from Athens is, however, Plato who was more a philosopher than scientist. (Incidentally, it is through him that we come to know of most of the thoughts of Socrates.) Plato did, however, have a fascination for mathematics, as the "purest form of philosophy" and tried to apply mathematical ideas to describe the heavens. He knew that there were five, and only five, regular solids. (A regular solid is the one with identical faces with all the lines and angles formed by the faces equal, see *Figure* 3.) These are the four-sided tetrahedron, the six-sided cube, the eight-sided octahedron, the twelve-sided dodecahedron and the twenty-sided icosahedron. Plato tried to fit the heavens in a model based on these 'perfect' solids. This insistence that heavens should reflect our ideas of perfection held sway in the ages to follow (see *Box* 2) .

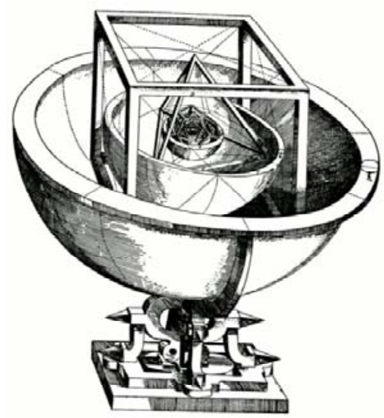
Figure 3. Platonic solids.



Plato established the famous Academy at Athens which influenced the philosophical thinking of people around the Mediterranean for

Box 2. Platonic Solids And The Music Of The Sphere.

The Pythagoreans and later Plato believed that the five regular polyhedra play a crucial role in nature. The 'atoms' of the four elements – fire, earth, air and water – were supposed to be in the shapes of a tetrahedron, cube, octahedron and icosahedron, respectively. (In the post-Aristotelian days, aether was identified with dodecahedron.) Centuries later, Kepler (1571–1630 AD) even attempted to model the orbits of the six planets known in those days, using the Platonic solids. He imagined a sphere with radius that of the orbit of Saturn, and inscribed a cube in it. He next put a sphere inside the cube, representing Jupiter's orbit, a tetrahedron inside it and a Martian sphere, a dodecahedron inside it with the terrestrial sphere, an icosahedron with the sphere of Venus, and finally, an octahedron with a sphere inside it representing Mercury's orbit. Interestingly enough, the radii of the orbits of the planet – calculated in this form – matched fairly well with the observed radii of orbits!



Kepler's platonic solid solar system

years. (In fact, it remained the stronghold of paganism in a Christian world in the coming centuries, and was ordered to be closed by Emperor Justinian in 529 AD.) Aristotle was the giant among the thinkers produced by the Academy and was, in fact, considered the "intelligence" of the Academy. Plato, however, named someone else as his successor, and Aristotle quit the school (probably) in protest! He was called to Macedon to tutor Alexander which he did for about six years. He returned to Athens later and formed his own school, the Lyceum, where he lectured for nearly 12 years. Aristotle's lectures at this school form virtually a one-man encyclopaedia of knowledge running over 50 volumes.

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His best contribution was in the field of biology where he made a careful and meticulous classification of animal species and arranged over five hundred animal species in different hierarchies. His classification scheme and ideas were truly 'modern'. For example, he classified dolphin with the beasts of the land because dolphins nourished the foetus by a placenta! (Later workers put dolphin back in the sea and it took nearly 2,000 years for biolo-

Plato and Aristotle as potrayed in Raphael's fresco 'The School of Athens' (1509–1510).

gists to set the record right.) He also made careful observations of the developing embryo of the chicken and the stomach structure of the cow.

Aristotle's attempts in 'natural philosophy' – what we now call physics – do not seem to be so successful. For some strange reason, he did not use the experimental and observational approach in these attempts. He tried to explain natural phenomena using the properties of five elements (earth, water, fire, air and aether – the last of which was his own innovation), by attributing a 'natural place' for each element. He believed, for example, that a heavier stone will fall faster than a lighter one, and, it seems, never bothered to check it. (The fact that he was wrong is to have momentous consequences, as we shall see in a later installment.)

Ironically enough, Aristotle was not as influential during his times as, for example, Plato. His works were published only after his death, and, soon after the fall of Rome were lost to Europe. These volumes, however, survived among the Arabs, who valued them dearly. Much later, in the 12th and 13th centuries, Christian Europe regained the Arabic texts and produced Latin translations. This led to Aristotle becoming the most influential ancient philosopher in medieval Europe.

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Suggested Reading

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