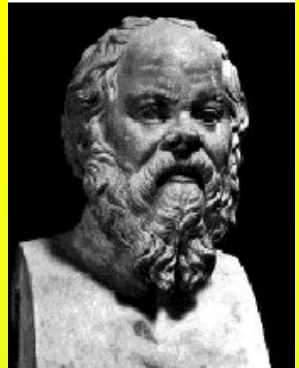


## Part II: PLATO & ARISTOTLE



Death of Socrates (David, 1787)

# Plato: the Quest after Ultimate Truth



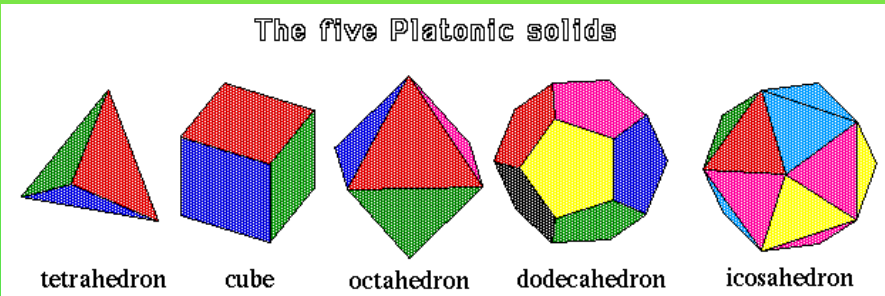
Socrates  
(470-399 BC)

Plato was heavily influenced by Socrates when young, and also by the death of Socrates. Socrates was condemned by an Athenian court to die (and did so by voluntarily drinking hemlock, refusing an offer to escape made by friends). The charge was corrupting the young (which he had done by philosophizing, in a way described in Plato's dialogues). This has immortalized the "Socratic method", which tries to elucidate a problem, or the truth of an idea, by dialectic (question and answer) inquiry.

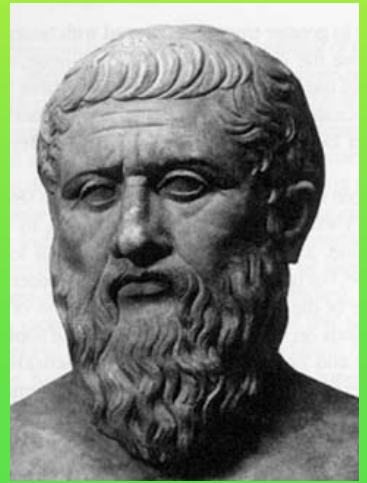
"Who then are lovers of wisdom (philosophers)?  
Those who seek to discern the ultimate nature of reality."  
Plato, *The Commonwealth*

The writings of Plato (which we apparently have in their entirety) are very wide-ranging. We are here concerned with those parts relevant to the physical world and our knowledge of it. We will concentrate on the "Theory of Forms" and its implications. This theory is introduced on the next slide, and discussed extensively in the Course Notes.

Apart from Socrates, Plato was heavily influenced in the formulation of his ideas by (i) the ideas of Heraclitus & Parmenides on change vs. constancy, and (ii) the developments in mathematics (notably by his friend Thaetetus, and by the earlier Pythagorean school). This led to an interest in geometry, including



solid geometric figures – although it is not clear how much Plato himself was involved in the study of these.



Plato (428-348 BC)

# PLATO: the THEORY of "FORMS"



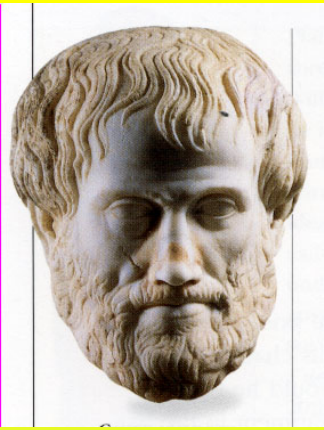
The key idea in the "Theory of Forms" was existence of a supra-sensible realm of "ideas" or "Forms", beyond the world of appearances. The argument for this was essentially one of abstraction from particular imperfect instances of things in the sensible world (eg., objects that were approximately circular), to the 'real' things, the universal 'Forms', like 'Circle', which could only be defined in the higher world of Forms.

From ideas about simple Forms like "Circle", Plato went on to discuss higher forms, culminating in the highest of all: the "Good".

Plato's Cave allegory likens our sense perceptions to the shadows of real objects cast upon the wall of a cave. The real objects, in this allegory, represent the higher "Forms" of which we have no direct perception. True knowledge is then knowledge of the archetypal forms themselves, which are real, eternal, & unchanging. Sense perception, then, does not give us access to reality, but only to an impermanent world of perception.

In modern physics, the ultimate constituents of matter resemble Platonic Forms: one deals with Fields and Probability amplitudes, as we will see. The irony is that the existence of these very abstract entities has been discovered by us, not by philosophical speculation or ratiocination, but instead by a combination of mathematical theory and experiment: ie., by a combination of the kind of mathematical deduction that Plato envisaged, together with the kind of experimentation that he apparently would have ruled to be irrelevant.

# Aristotle: the Real World



Aristotle (384-322 BC)

Aristotle was the most illustrious student of Plato; he was a pupil in his school “the Academy” and later founded his own (the “Lyceum”). He himself was a teacher to the young Alexander the Great- who later conquered & changed the whole of the known world as far as India, Vastly extending the influence of Greek ideas & culture (perhaps in line with Plato’s ideas on the role of education!). The influence of Aristotle on later European culture was colossal.

Aristotle classified and organized the whole of Greek thinking, in a way so comprehensive and detailed, & with such perception, that modern education is still designed along the lines he laid out. We only have later versions of his writings, the originals being lost (in, eg., the fire in Alexandria).

For us the principal interest of Aristotle is in his denial of Plato’s supra-sensible world- he argues instead for a single physical world. The fundamental “stuff” of this, which he called “substance”. Any object in the world was described in terms of 4 ‘Causes’:

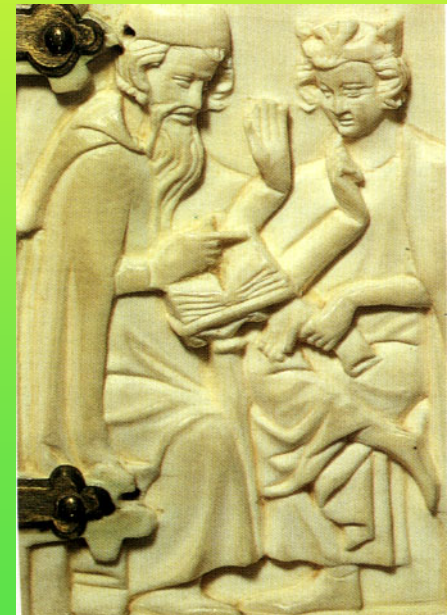
**Material Cause:** the matter from which it is made

**Formal Cause:** the form the matter takes

**Efficient Cause:** the influences/agencies acting to change the object

**Final Cause:** the purpose or goal of the object and of the changes

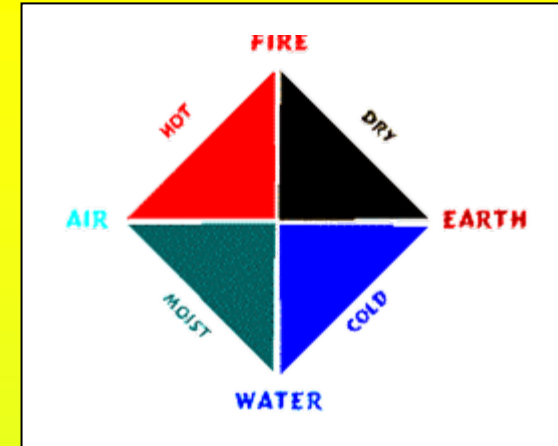
Only one of these (the efficient cause) conforms to the modern use of the term ‘cause’. For Aristotle, it was impossible to separate any of these causes from the others – it was meaningless to talk about ‘form’ or ‘Forms’ separately from the rest. The fundamental nature, including the very existence of an object, resulted from its 4 Causes.



Aristotle & Alexander

# Aristotelian Picture of Nature

In Aristotle's theory, the 4 Empedoclean elements (earth, water, air, & fire) are involved in the Material Cause of an object, but these only exist in the sub-lunar realm. The superlunar realm was a plenum of the 5<sup>th</sup> element (quintessence). The 4 sub-lunar elements are themselves made from various proportions of more fundamental pairs of opposites such as hot – cold, or wet – dry (the Fig. at right shows how this was done), and also heavy – light.



There was no void in the universe according to Aristotle. Nevertheless change was possible – there were both 'natural' and artificial changes of objects, including their motion. Natural changes occurred under the influence of the 4 Causes. However it was also possible for the changes or motion to be 'forced', ie., not conforming to the fundamental nature of the object. For example, if a javelin is thrown, according to Aristotle the motion is forced when thrown, but thereafter continues under the action of the surrounding medium, which pushes it along. Thus for Aristotle no continuous motion could occur without a force acting continuously on the object. Although Aristotle did not describe things quantitatively, he was often saying that

$$v = F / m$$

where  $v$  is the velocity,  $m$  the mass, &  $F$  the total force on the object. This force included both the applied force and the resistance from the medium. Unfortunately he is unclear on this – thus in the discussion of the superlunar realm, where there is no resistance to motion, he argues that there is no force since otherwise the object would move at an infinite velocity, a statement incompatible with the equation above, instead implying that

$$v = F / R$$

where  $R$  is the resistance to motion from the medium. It has to be admitted that here, as well as in his distinction between natural & forced motion, Aristotle's ideas are a bit vague and incoherent (see Course notes). For his Cosmology, see later on.