

An Introduction to the History of Scientific Ideas in Western Culture (Talk 1)

A Summary of Greek Science and its Legacies

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Greek science

- * The Myths
- * The Pre-Socratics (including Pythagoras)
- * The Sophists
- * Socrates
- * Plato's Theory of Ideas
- * Aristotle's Teleological Universe (Nature as a living organism)
- * Greek influence on the development of science (secular scepticism and metaphysical idealism)

Acknowledgements/references: Hesiod; Tarnas; Bertrand Russell; Antony Flew; Freeman Dyson; Roger Penrose; Victor Weisskopf

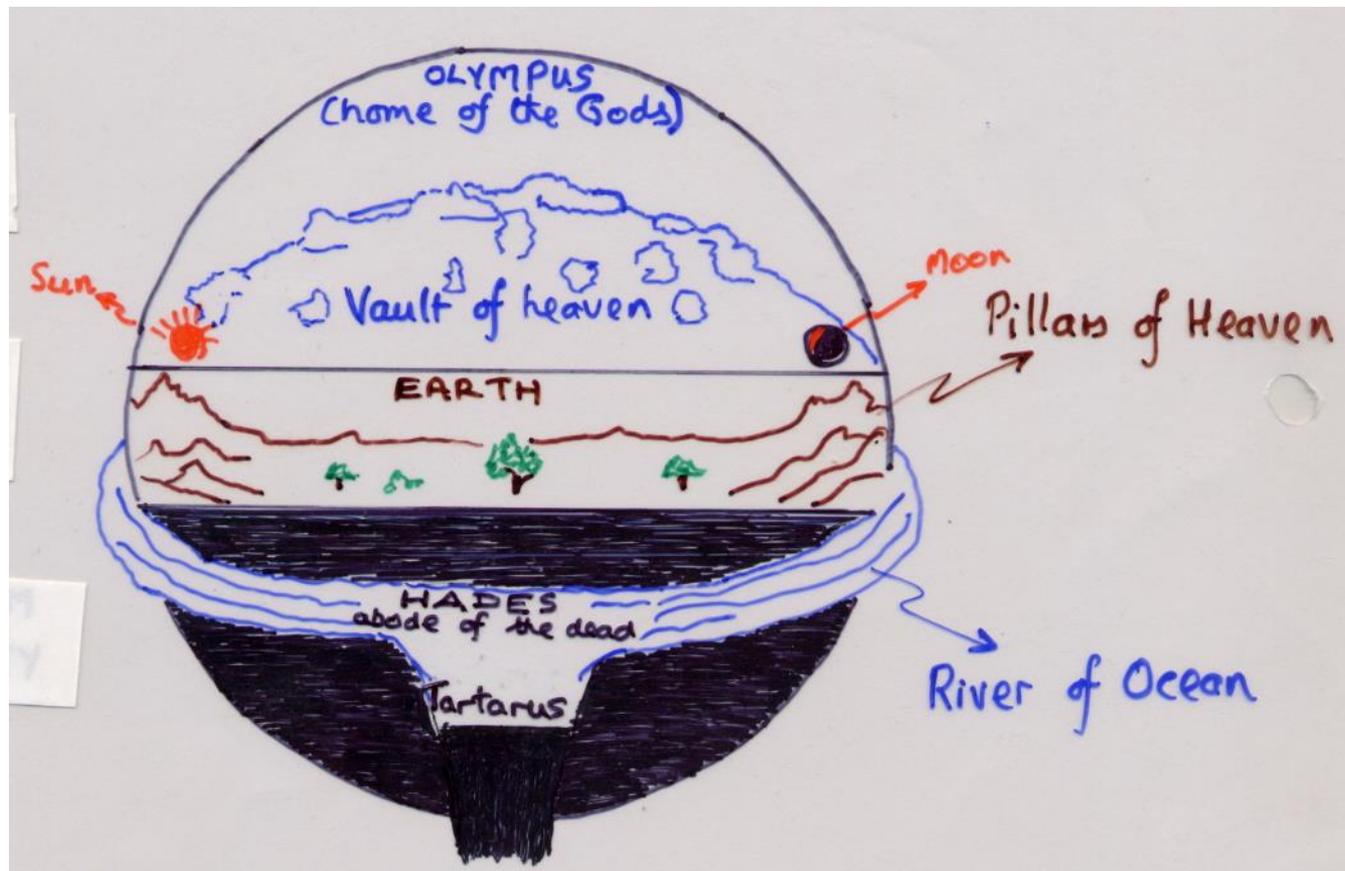
The Greek Myths – Hesiod's *Theogony*

Story of coming into being of the whole of creation from a state of primordial chaos.

In terms of the interactions (including sexual and asexual reproduction of gods).

Some gods (e.g. Gaia, the Earth; and Ouranos, the Starry Sky) are physical features of the world we inhabit.

So: at this stage, *theogony* (the genealogy of the gods) and *cosmogony* (the creation of the physical universe) are linked.



First of all there came chaos
and after him came
Gaia of the broad breast,
to be the unshakable foundation
of all the immortals who keep the crests
of snowy Olympos ...

But Gaia's first born was one
who matched her in every dimension,
Ouranos, the starry sky,
to cover her all over,
to be an unshakable standing-place
for the blessed immortals.

The Pre-Socratics

The Milesian Natural Philosophers

- * Thales (c 624 BC – c 546 BC) - water
- * Anaximander (c 611 BC – c 546 BC) - apeiron
- * Anaximenes (586 BC – 526 BC) - air

Comments

- * Aware of problems – e.g. illogicality of finite things existing in boundless universe made of one substance
- * Fundamental substances had eternal nature, and were often identified with gods

Heraclitus (535 BC – 475 BC) - fire

- * Introduced idea that the universe and its changes are governed by a **cosmic reason** or **logos**.

[Pythagoras (c 570 BC – c 480 BC) and the Harmony of the Spheres

Pre-Socratics - materialist, focused on basic stuff
of the universe

Pythagoras - holistic vision

Penrose: ... it unites religion and science,
mathematics and music,
medicine and cosmology,
body, mind and spirit ...

- musical note: halve length, double frequency

(Deep mystery – why is nature amenable to a
mathematical description? (Wigner paper))

Pythagoras: numbers and mathematics sacred.

e.g. he regarded mathematical ratios (2:1 for an octave, 3:2 for a fifth, etc) as music – pure and eternal.

We hear – imperfect this-worldly versions of this *mathematical music*.

Pythagoras: cosmology

- * Heavenly bodies move in perfect circles – pictured as the ‘strings of a cosmic lyre’.
- * Radii of circles simply related, producing cosmic music – pure and eternal – the ‘harmony of the spheres’.
- * Music of the mind/soul, not something human ears can hear.

Pythagoreans held a **mystical/religious** view of maths

The everyday world of our **senses** falls short of this.

This mindset was picked up by Plato (*Theory of Ideas*)

The combination of mathematics and theology, which began with Pythagoras, characterised religious philosophy in Greece, in the Middle Ages, and in modern times down to Kant ...

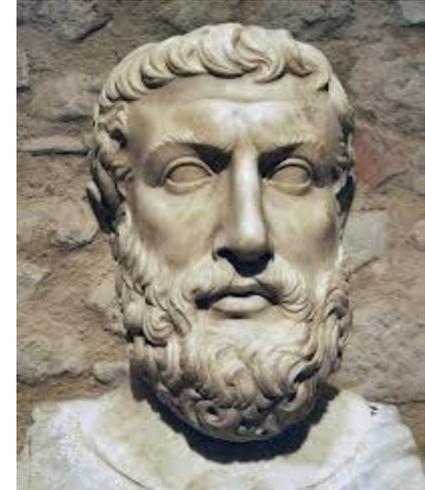
I do not know of another man who has been as influential as he was in the sphere of thought.

Bertrand Russell]

Parmenides (c 515 BC – c 450 BC)

Senses – transitory phenomena
Reason – reality - eternal

Anticipates Plato's *Theory of Ideas*



Anaxagoras (c 510 BC – 428 BC)

(A great before-his-time astronomer)

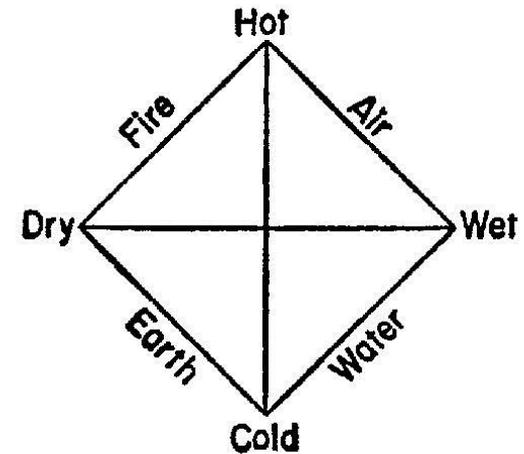
- * Each bit of anything contains some of everything. Differences are controlled by the relative proportions.
- * Proposed the existence of a cosmic mind-substance (**nous**) which enters things when they become living. (Picked up by Aristotle)

Despite his **nous** idea, Anaxagoras was pre-Socratic in spirit, **mechanistic (like Milesians)** not **spiritual (like Pythagoreans)**.

Empedocles (c 495 BC – c 435 BC)

- * Earth, water, fire and air picture

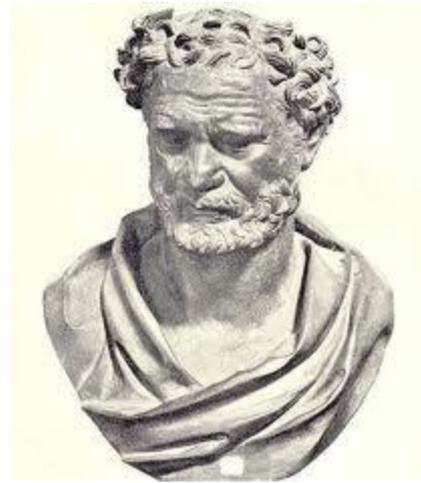
Behaviour and variety of matter results from combinations and re-arrangements of these elements.



Xenophanes (c 571 BC – c 475 BC)

- * Rejected gods with their human weaknesses
- * Postulated all-pervading God with no human characteristics.

Leucippus (c 460 BC – c 370 BC) and
his pupil **Democritus** (c 460 BC – c 370 BC)



Matter – made of completely solid, homogeneous, invisibly small atoms, moving in a void (controversial).

Atoms can differ in size, shape and weight.

So what?

Dramatic – challenging the idea that the world *is a stage on which spirits and gods act according to the impulses of the moment and in a more or less arbitrary fashion ... but is something which could be understood if someone dedicates himself to observing it attentively ...*

SCHRODINGER

Witnessing things that look a bit ‘scientific’:

- * birth of idea that universe is **rational**
- * seeds of **empiricism** – idea that knowledge of the world is gained by our senses

- * 1st time in history: the thought that man could understand the world undermined faith in myths and gods, and raised the status of humans – ‘**birth of *humanism and secularism***’.
- * But level of understanding was very low – many uncertainties!
- * Despite this, secular humanist spirit emerged in the form of the **sophist** movement – itinerant fee-charging teachers – considerable influence in Athens.

Pragmatic approach: turned the uncertainties of their heads ... sophists start with idea that there are no absolutes such as absolute truth.

Each person, using his or her own thoughts and experiences, comes to his or her own individual truth. (Relativism.)

- * Starting here, how could the sophists have made money as teachers? How can you teach if you deny knowledge?!

* Sophists taught life-skills such as argumentation and rhetoric.

‘Sophistry’ – showy and fallacious reasoning in order to deceive, mislead, persuade, or defend a point regardless of its value or truth. (Partington)

* Sophists had brief spell of popularity. Can debate the extent to which their denial of absolutes such as justice and truth, and the cynical attitudes towards human dealings, were responsible for the moral decline in Athens life.

The Golden Age of Greek Philosophy – Socrates, Plato and Aristotle



Plato – pointing upwards - 'world of ideas', rationalism
Aristotle – pointing downwards - observe with senses; empiricism

Socrates (470 BC – 399 BC)

Objected to 'mechanistic philosophers':

- * Building-block approach ignores the essential unity/inter-relatedness of nature
- * Life and humanity relegated to an insignificant position
- * Possibilities (EAFW, maths, atoms ...) arbitrary mutually inconsistent

Years of dialogue, meditation, self-searching ... led to his **Theory of Ideas** (in writings of pupil Plato).

Plato (c 428 BC – 347 BC) – Theory of Ideas

Key features:

- * Universe is evolving rationally and with purpose, under the influence of a divine cosmic intelligence (or God)
- * Sense knowledge is illusory because
 - our senses are unreliable
 - things that we sense have a transitory existence
- * Beyond our senses there exist a ‘world of ideas’ which are eternal and immutable; these ultimate realities are accessible to our minds/souls; e.g. idea of truth, beauty, cat, goodness ...

Creator of world of ideas – ‘demiurge’ – **first appearance of a ‘divine creator’ in Western thought**

Plato's Theory of Ideas

**ETERNAL and
IMMUTABLE things**

?

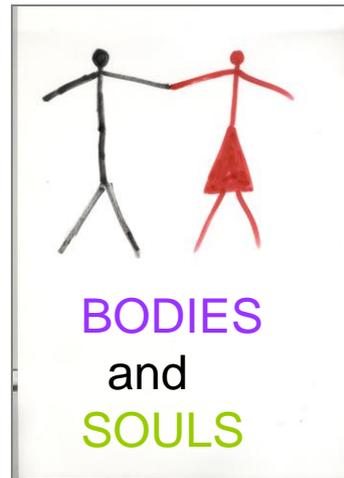
**'FLOWING' or
CHANGING things**

**REALITY – the
WORLD of IDEAS**

**MATERIAL WORLD –
WORLD of the SENSES**

TRUE KNOWLEDGE

**Using our minds/souls
we access the world of
ideas with reason**



OPINIONS

**Using our bodies with their
unreliable and changing
senses, we form opinions**

The Allegory of the Cave (from Plato's *Republic*)

- * Men ... prisoners in a cave ... bound ... can only look in one direction ... fire behind them casting shadows of men and objects behind them ...
- * Men see only shadows ... think they're real .. unaware of actual objects
- * One prisoner escapes into the light ... sees real things ... and realises how he's been deceived by the shadows ...
- * Knows truth for the first time ... remembers darkness with sadness ...
- * The real philosopher, possessing real knowledge, is the prisoner who has escaped from the darkness of mere sense information ... **higher level of truth exists** ...

Plato – the most influential Western philosopher:

- * For 2000 years the problem that dominated human thought was the connection with this higher level of truth
- * In particular, the soul and its relation to the creator of the world of ideas – who later became ‘identified’ with the God of the Judaeo-Christian tradition.
- * Ethics ...

Meanwhile, what was happening to SCIENCE?

- * **Aristotle: greatest influence on natural philosophy**

Aristotle's Teleological Philosophy

(Nature as a living organism)

Introduction

- * Socrates/Plato: ' ... this world came to be in very truth ... a living being with soul and intelligence'.
- * Aristotle rejected Plato's world of ideas ... argued that things we perceive with our senses are real ... and we should apply our reason to such facts ('empiricism')
(Made big contribution to biology)
- * To explain what he means by 'real', Aristotle introduces 2 concepts – **substance** and **form**.

Substance: material a thing is made of.

Form: thing cannot be perceived until substance is united with form.

Form gives thing its characteristics ... particularly the ability to change from a current potential state to a later actual final state.

E.g. the **form of an egg allows it to change into a bird and not an apple!**

Idea we're working towards: **it is in the nature of everything to move spontaneously towards its end and the the purpose of its existence is to achieve that end.**

Aristotle's Goal-oriented ('teleological') natural philosophy

Comments

- * Teleology even applies to inanimate objects like stones:
drop spontaneously to earth because the purpose of their existence is to do so ... natural place for stone (made of earth) is on the earth.
- * It is this purposeful behaviour that characterises the **Greek view of the universe as a living organism.**

Tell OVB story!

- * Summarise Aristotle's universe and ideas on motion

Aristotle's universe

Two concentric spheres:

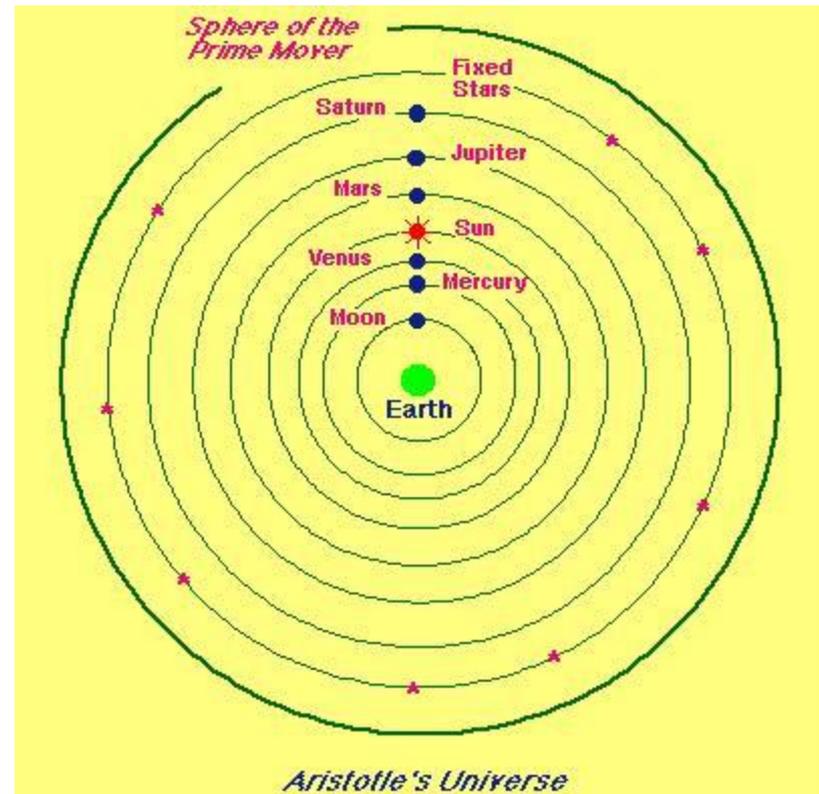
* Terrestrial, nearly up to moon

Made of E W A and F in that order

* Celestial or heavenly from moon upwards

Made of one element (aether or quintessence) – so no changes possible.

Celestial sphere gets more divine as one rises from the lunar sphere to the sphere of the **Prime Mover**.



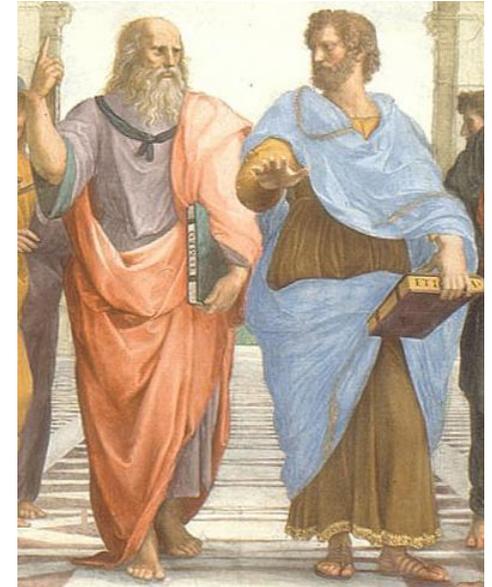
Prime mover imparts circular (perfect) motion to the sphere of fixed stars, from where it is transmitted downwards eventually reaching our earthly sphere.

[An aside:

Aristotle's 'God' and Plato's 'God'

Some scholars think that Aristotle's view of the Prime Mover being directly responsible for the motion of the stars and planets has caused difficulties:

- * for science because it makes God part of physics (not the way we see it nowadays)
- * for theology, because it makes the motion of the stars and planets a part of theology.



Plato's 'God' is more abstract, being the creator of the world of ideas, not part of the physical universe we live in and experience with our senses.

... end of aside.]

Motion in the terrestrial sphere - Aristotle

* Straight line, up or down, and **finite** - **NATURAL**

* All motions not NATURAL are called - **VIOLENT**

$$Velocity = \frac{Force}{Resistance} \quad \text{or} \quad v = \frac{kF}{R}$$

where the force must either

* reside in the body (as for inanimate objects), or

* be in direct contact with the body

NB For Aristotle: forces produce motion (velocity)

Greek Influence on the Development of Science

- * **First to think that the universe is rational, accessible to the human mind.**
- * **Led to establishment of 2 intellectual traditions**
 - (i) **Secular scepticism**: an amalgam of pre-Socratic thought ... a sort of naturalistic empiricism, some rationalism (e.g. Parmenides), mechanistic materialism (Democritus); and the sceptical ideas of the sophists with their secular humanism and elevated view of man in the universe.
 - (ii) **Metaphysical idealism**: a coming together of rationalism and Greek 'religion' in the spirit of Pythagoras, Plato (even the 'empiricist' Aristotle).

The beliefs behind secular scepticism

- * Genuine knowledge come from empirical observation and human reason
- * One must search for truth in the (*immanent*) world of experience, and not some (*transcendent*) other-worldly reality.
- * Natural phenomena are caused by impersonal, this-worldly physical effects; not mythological or supernatural effects. (Including mathematics?)
- * Theory must be measured against empirical reality.
- * Knowledge is never final ... but revisable in light of new empirical evidence.

The beliefs behind metaphysical idealism

- * Universe is ordered ... similar to order of the human mind; so a rational analysis of the universe is possible
- * Universe 'possesses' an intelligence that is accessible to human awareness, if developed to a high enough degree.
- * Intellectual analysis, at its most penetrating level, shows that the universe has a timeless order that goes beyond the world of our senses; there is a deeper, eternal reality which is both the source and goal of our existence.
- * To get at this deeper level of knowledge we need to use a plurality of human mental faculties – rational, empirical, intuitive, aesthetic, imaginative, mnemonic and moral.
- * This deeper level of apprehension is not only intellectually decisive, but also spiritually liberating.

Comment:

The constant interplay of these two partly complementary and partly antithetical sets of principles established a profound inner tension within the Greek inheritance, which provided the Western mind with an intellectual basis, at once stable and creative, for what was to become an extremely dynamic evolution lasting 2500 years.

The Passion of the Western Mind
(Tarnas)

To see, let us fast-forward 2500 and consider the words of **Freeman Dyson** of the Princeton Institute for Advanced Studies on The Role of Science in Human Understanding

Two extremes:

The reductionist view, holding that all kinds of knowledge, from physics and chemistry to psychology and philosophy and history and ethics and religion, can be reduced to science. Whatever cannot be reduced to science is not knowledge ...

The traditional view, that knowledge comes from many independent sources, and science is only one of them. Knowledge of good and evil, knowledge of grace and beauty, knowledge of ethical and artistic values, knowledge of human nature derived from history and literature or from acquaintance with family and friends, knowledge of the nature of things derived from meditation and religion, all are sources of knowledge that stand side by side with science, parts of a human heritage that is older than science and perhaps more enduring ...

Extra assorted slides

These developments in natural philosophy which span a period of 2-3 centuries had a huge impact on Greek culture. A particularly significant period came towards the middle of the 5th century BC: Athens had become wealthy and powerful after the 2nd Persian War (481-479 BC), and it supported a flowering of the arts – drama and poetry, philosophy, history, sculpture and architecture – inspired to a great extent by the Olympian gods.

However, the idea that the material world was rational - accessible (and similar) to the human mind - was deeply dramatic in that it challenged the idea that the world

is a stage on which the spirits and gods act according to the impulses of the moment and in a more or less arbitrary fashion ... but is something which could be understood if someone dedicates himself to observing it attentively ...

Erwin Schroedinger

Witnessing something that looks a bit ‘scientific (the word ‘science’ was not coined until the 19th century)’:

- * Birth of idea that universe is rational
- * Seed of empiricism – the idea that knowledge the world is gained from our senses

Perhaps for the first time in human history, a 'realisation' (perception is probably a better word) that man (it was men in those days) was capable of understanding the world undermined faith in myths and gods, and raised the status of human beings (in their own eyes, at least!).

One might call this the birth of 'humanism' and 'secularism', and the intellectual movement as the First Enlightenment.

It is worth noting that, at the time, the intellectual climate, as far as ideas about the nature of the universe were concerned, was very uncertain: earth, air, fire, and water; mathematics; atoms in a void. These ideas, based mainly on thinking, with a little observation perhaps, were not consistent with each other and there was no way of deciding on their relative merits.

Despite this, the secular humanist spirit emerged in the form of the 'sophist' movement – itinerant, fee-charging teachers - and had considerable influence in Athens.

Their approach was extremely pragmatic: turning the uncertainties just mentioned on their heads, the sophists began with the idea that there are no absolutes such as absolute truth. Each person, using his or her own thoughts and experiences, comes to his or her own individual truth. (Relativism.)

One might wonder how, starting from this point of view, the sophists made much of a living as teachers. What could they teach if they denied the existence of knowledge?!

They ignored the myths and ideas about the nature of the cosmos and taught what we might now term 'life-skills' such as argumentation and rhetoric. The word sophistry now means 'showy and fallacious reasoning in order to deceive, mislead, persuade, or defend a point regardless of its value or truth'. (Partington(?) Dictionary of Philosophy.)

The sophists enjoyed a spell of popularity but their influence waned later in the century. One can debate the extent to which their denial of absolutes such as justice and truth, and their cynical attitudes towards human dealings, were responsible for the moral (?) decline in Athens life.

Aristotle on motion in a void

(Inertia in the Middle Ages (Allan Franklin) TPT April 1978 pp.201-208)

* Believed impossible:

(i) no medium to sustain the motion;

(ii) absence of resistance would lead to infinite speed,
an unacceptable solution.

Possibly Aristotle's most significant statement on the void.

‘Further, no one could say why a thing once set in motion should stop here rather than HERE? So that a thing will either be at rest or must be moved *ad infinitum*, unless something more powerful get in its way.’

- * A surprisingly modern statement of the principle of inertia ... brings to mind the fact that momentum conservation is a consequence of physics being symmetric wrt translations in space.
- * BUT: Aristotle used it to prove that motion in a void is impossible: such motion would be unacceptable (to A) because it would imply infinite motion in the terrestrial sphere.

Excerpt from Plato's *Sophist*

STRANGER – We have not gone through all those who give a precise account of what is and what is not. However, let that suffice. Now we must turn our attention to those who speak on a different level, so that we can know from all sources that it is no easier to say what being is than what is not being.

THAETETUS – Very well then, we must go on to them.

STRANGER – Look then, for there seems to be a sort of Battle of the Gods and the Giants going on among them because of their dispute about existence.

THAETETUS – How so?

STRANGER – One side drags down everything from heaven and the unseen to earth, rudely grasping rocks and trees in their hands.

STRANGER (contd) – For they get their grip on all such things and they maintain that that alone exists which can be handled and touched. They define body and existence as the same thing, and if anyone says that one of the other things which does not have body exists, they completely despise him and are unwilling to listen to another word.

THAETETUS – Terrible men they are of whom you speak. I have met with a lot of them in my time.

STRANGER – For that reason those who battle against them defend themselves very carefully from somewhere above in the unseen, contending that true existence consists in certain incorporeal Forms which are objects of the mind. But they pound the bodies of their opponents and what these call truths into small pieces in their arguments, denouncing it as a sort of motion or becoming. There is always, Thaetetus, an interminable battle going on between these camps about these

THEATETUS – True.

Comments by Antony Flew

The Giants essentially argue that **‘all there is is stuff; and whatever is not stuff is nonsense.’**

To defend themselves against such materialist Giants, the Gods indeed have to ‘defend themselves very carefully’.

To win – **need examples of things that are undoubtedly incorporeal, but can be shown to exist.**

One any incorporeal objects are admitted – whether Plato’s Forms or others – then not only are the negative claims of the Giants defeated but the door is also ajar for the admission of yet further incorporeals belonging ‘somewhere above in the unseen’.

But, there is uneasy tension in this euphoric intellectual state:

- * No agreement about the basic stuff, or about nature's rich variety of phenomena
- * Status of myths – ambiguous – e.g. Anaxagoras
- * Not much said about the idea of 'life'
- * What is ultimately behind it all? Variety of ideas ...

A

B

C