

the PRE-SOCRATIC PHILOSOPHERS

The appellation 'pre-Socratic' is a little misleading, since it refers to a number of philosophers who were contemporaries of Socrates, and excludes both Protagoras and Socrates. It actually refers more to a brand of philosophy, dominated by an interest in the Natural world, mathematics, form, etc., and a quest to understand origins, mechanics, and to formulate hypotheses about the world. The ideas of Socrates, developed by Plato and Aristotle, instead allotted much more importance to social, political, and moral questions, and in doing so consciously reacted against the 'pre-Socratics'. Unfortunately most of what we know about the pre-Socratics comes from Plato and Aristotle, along with a number of other commentators (notably Theophrastus); we have almost none of the original writings of these philosophers. This is a great shame, but somewhat inevitable- as we shall see later, we are rather lucky to have *any* of the contributions of the Greeks available today.

For our purposes the most important thing about the pre-Socratics is (i) the extent to which they anticipated both the later Greek ideas (indeed, some of the key ideas of Plato started from Heraclitus and Parmenides on the philosophical side, and from the earlier Pythagorean work in mathematics); and (ii) that their ideas in many ways represent the very beginnings of what we now call scientific enquiry. For this latter reason alone they deserve our attention- for although the beginnings of any really new area of human thought are always hard to understand, being inevitably somewhat disorganised, they are the crucial leaps that have brought us to where we are now. One learns a great deal by studying such leaps.

In what follows we cover those 5 main strands of thought coming from the pre-Socratics that were non-mathematical in their content. This means that only a partial discussion of Pythagoras is given here- a more complete discussion of his mathematics appears in the later section on Greek mathematics.

(1) The Milesian School: Differentiated Unities

This school of thought existed in Miletus, on the coast of Asia Minor (now western Turkey- see map), in the period from roughly 590-530 BC. The influences on this school came from Babylonia (particularly Babylonian mathematics and astronomy), Egypt, and father East. The technology developed by these earlier civilisations also strongly influenced the Milesian philosophers, but in an important and very non-trivial step, they consciously rejected the prevailing religious picture of the day, according to which the heavens were inhabited by anthropomorphic Gods, and the world was full of magic, manipulated in mysterious and often capricious ways by these Gods, and the explanation for events were buried in the myths and legends extending over the previous millenium. Instead of seeking explanations in terms of ineffable divine causes, the Milesians turned to the natural world, looking for causes entirely inside this world, and inventing explanatory hypotheses and general frameworks to deal with the amazing variety of phenomena at their doorstep. This was a radical shift, and of course not accomplished all at once. Their ideas were still strongly influenced by the older cosmogony, according to which the world originated from an undifferentiated or amorphous unity (a theme which continues to appear in religious writings up to the present day). This idea was central to the texts then existing in Hebrew, Egyptian, Babylonian, and Greek (in Babylonian and Egyptian cosmogony, the universe began as an undifferentiated infinity of watery cloud).

Miletus was at that time a prominent port and trading centre between East and West. We can probably assume that the 3 main Milesian philosophers knew each other- it is thought that Anaximenes was a pupil of some sort of Anaximander, but we don't know for sure.

(a) **THALES:** The dates of Thales are unknown- he was certainly active in 585 BC, when he is supposed to have successfully predicted a solar eclipse. He was an engineer and an advisor to the Milesian king, and is also supposed to have measured the distances of ships out at sea. Very little is known for sure about his life beyond the speculations of later commentators.

For Thales everything in the material world was some form of water- this for him was the result of a search for some kind of all-embracing unity. He also had the rather odd idea (which again predated him, coming from the Egyptians) that the Earth floated on water. According to this hypothesis, water could take on many forms- indeed, it was capable of transforming itself and differentiating into all that we see in the material world.

(b) **ANAXIMANDER** (610-546 BC): In common with Thales, Anaximander also did serious astronomical and cartographic work. He was the first Greek to make a world map, prepared the first Greek star map, and also built a celestial sphere, with a cylindrical earth at the centre, and concentric celestial circles outside, thereby making a model of the universe. The earth remained at rest at the centre because it was in the centre of symmetry- he apparently imagined that there would be some kind of balance of forces at this point. Anaximander also write a book ("*On the*

Nature of Things”), in which he laid out his astronomical and philosophical ideas.

This astronomical hypothesis went in hand with his cosmology. According to Anaximander, the primeval or fundamental ‘stuff’, which he called ‘*apeiron*’ (meaning ‘boundless’ or ‘limitless’), was everlasting and infinite, and also imperceptible- a kind of ineffable ether. He gave an elaborate theory of how everything ‘grew’ out of *apeiron*; this involved in an essential way 2 pairs of opposite principles, called Hot/Cold, and Wet/Dry. According to Anaximander, various things were ‘spun off’ from the *apeiron*, by these principles- this began with a sphere of fire, which itself differentiated to form the heavenly bodies, themselves wheel-like compressed air, full of fire, with orifices from which this fire issued (eclipses being explained as blockages of these orifices). The process of separation continued to form land, sea, air, and everything else on earth, including living things- he even postulated a kind of evolution of species.

The idea of *apeiron* is interesting- he recognised that this primeval stuff had to be different from everything we are aware of- it had to be everlasting, the generator of all transient and perishable things in the world. Otherwise it would not be fundamental, but just another part of Nature. Anaximander also saw *apeiron* as governing the whole of the cosmos and its changes- in this way it held the earth at its centre, and provided the motive power and energy which drives all things. For him it was ageless, immortal, and divine, and the mover/creator of everything that exists.

(c) **ANAXIMENES** (died 528-526 BC): Little is known about the life of Anaximenes. His philosophy was in some ways a reversion to that of Thales- instead of water he postulated air as the primitive stuff. All things then came from the compression, rarefaction, or transformation of this air. All these transformations are accomplished by ‘Hot’ and ‘Cold’. In contradistinction to Anaximander, these principles are not something that separate off from the primitive stuff, or even just agents of change and transformation- they are instead ‘attributes’ of air, i.e., properties of it. In the same way as Anaximander, Anaximenes apparently also gave an elaborate theory of how various things were formed on earth and in the heavens, starting from these ideas.

The most important contribution of the Milesians was to introduce the idea of a fundamental stuff, which some process of differentiation gave the natural world. This was a big step away from the previous cosmogonies, which were essentially religious and usually anthropomorphic. Instead one had a natural philosophy, with natural causes, regular mechanism of operation, speculative physical hypotheses, and the idea that the primal cause and ‘substance’ could be imperceptible and all-pervasive. The idea of Anaximander, to make this divine, was to have great influence later on.

Perhaps the most interesting thing, from our point of view, is that the Milesians were dealing with empirical propositions based to some extent on observations about the world. Thus we are talking about the act of ‘hypothesizing’ about the world, in a pre-scientific way.

(2) Ideas about ‘Form’

The problem with exclusive concentration on the natural world is that it is impermanent, in a state of constant flux- if one is seeking an explanation for all things, it cannot therefore be found in the world of everyday phenomena. This was of course recognised by the Milesians, but they did not attempt to get to grips with the structure and form of the ineffable underlying ‘stuff’, treating it as undifferentiated.

In what may be one of the most important intellectual steps ever taken by mankind, such studies were initiated by the Pythagorean school, in a move which led to the creation of crucial parts of ancient mathematics. The later ideas of Heraclitus were in part a reaction to both Pythagorean and Miletian work.

(a) **PYTHAGOREAN SCHOOL**: Pythagoras was born around 570 BC on the island of Samos, in Ionian Greece just off the coast of Asia Minor (what is now the Turkish coast), near the coastal towns of Miletus and Ephesus. It is said by some that he was a student of Thales of Miletus. Pythagoras left Asia Minor, apparently because of the policies of the tyrant Polycrates, and travelled widely, eventually settling in Croton, in Southern Italy. The school he founded there was very influential (notably on Plato); adherents wore a star pentagram symbol, and were distinguished by a strongly mystical philosophy. The school was initially very influential in Croton and environs, but after a revolt led by Cylon, in which a number of the school were killed, Pythagoras fled to Metapontum, and the school was reconstituted- however it was later persecuted and the survivors were dispersed as far afield as Thebes (southern Egypt), Phleius, and Tarentum. A split appears to have occurred at some point between 2 branches of the sect- the *acusmatiki* and the *mathematiki*. We do not have much direct evidence of their activities (much of what we know comes from Plato, Aristotle, and their students), since the sect appears to have been somewhat secretive in both its activities and the arcane knowledge and ideas it possessed. All this alerts us to the utterly different culture we are dealing with here- instead of a group of armchair mathematicians or philosophers in a university lab, we are talking about a secret religious sect with various hidden political and social aims, as well as a variety of rituals and

taboos. One should get used to this in trying to understand the beginnings of science- Newton was hardly different in his approach to Nature.

From what we know of Pythagoras he appears to have been one of the greatest intellects of the Ancient world, perhaps of all time, held in some awe by later Greek thinkers- his influence on Plato and Aristotle, some 150 yrs later, was enormous. His philosophy fused Orphic religious traditions with a belief in rational inquiry into the nature of the *kosmos*. The latter was viewed by him as *alive*, a living creature. For Pythagoras, the cosmos was a whole, without *telos* (end); we are all part of it (at least our souls are). The Pythagoreans believed in transmigration of souls- meat was forbidden, as were beans, since they might conceal the soul of a former friend (at least according to later parodies). Philosophy is the attempt to study and understand the cosmos- and in the end, philosophy is assimilation of the pupil to the divine cosmos. The *kosmos* represented for Pythagoras a kind of inherent order or structural perfection, a divine pattern or form. This was a remarkable new idea which broke completely from the Milesian school, which was essentially materialist and interested in the constituents of matter.

The essential tool for this study of form and structure was mathematics- which revealed the form of the cosmos (for more on the mathematics of Pythagoras, see section on Greek mathematics). Numbers were viewed as divine, the key to the *kosmos*, and their properties thereby revealed patterns in the cosmos. For Pythagoras, *everything* in the cosmos was an emodiment of number, even things like justice. Most notable of the patterns found in the cosmos was the harmonic relation, also revealed in music- this led to the whole idea of the music of the spheres, in which the planetary orbital periods corresponded to musical intervals. The living cosmos had no end but it did have a beginning- it began with a 'seed' in the infinite, which was afire in its centre- this proceeded to grow by drawing in the infinite from outside itself, and giving it structure by numbers. This process of drawing in was called 'inspiration' (ie., breathing in). Later neo-Pythagoreans like Philolaus (5th-century BC) even argued that the earth was a planet revolving around this eternal fire- a remark which was picked up 2000 yrs later by Copernicus (we come to this in later notes).

Much of what we know about Pythagoras came from later writers like Plato, and it is hard to sort out what he or his followers really said. His influence on Plato was very great- Plato adopted wholesale the Pythagorean ideas of the immortality of the soul, and the mathematical basis of the cosmos- he also followed Pythagoras in viewing philosophy as a means of reaching towards the divine, lending to it an exalted status which was terribly influential in Socrates, Plato, and much subsequent work. The most important philosophical idea from Pythagoras was that the most fundamental explanations were not in terms of matter or 'stuff', but in terms of abstract form. This was a hugely important step, whose consequences were to be worked out by Plato in some detail. The antithesis between matter and form, and the central role of mathematical form, is absolutely central to modern physics, as we shall see.

(b) **HERACLITUS**: Almost nothing original survives from Heraclitus, who was active sometime between 500-460 BC, in his hometown of Ephesus. The crucial idea we are interested in is his attempt to deal with the obvious fact that in the world we are aware of, everything seems to be changing in one way or another. Heraclitus regarded this dynamic quality as fundamental rather than illusory- arguing that in some sense instability was basic to the world.

According to Heraclitus, everything in the perpetual world takes place according to the '*Logos*', which here is translated roughly as a combination of principles and truths about things, 'natural laws', proportions, or in a modern terminology, 'formulae'. What form did this take? For Heraclitus the fundamental *logos* was the unity of opposites, and the existence of balanced strife between the opposites- one can say that the *logos* was opposition and strife. This *logos* had a material aspect, which it is not correct to think of as 'stuff'- it was not material. This was fire- and this apparently because it was the means by which things were transformed from one form to another- Heraclitus remarked that 'Fire steers all things'. Examples of opposites that he gave were beginning/end, day/night, young/old, living/dead, awake/asleep, hot/cold, wet/dry. The idea is that all change comes from the transformation between opposites, and that without some sort of 'dynamical equilibrium' between the opposites, so that the opposition was unbalanced, all strife and indeed change would eventually cease. Thus everything is in a perpetual state of flux, and no thing is ever the same. His famous aphorism, that 'one never steps in the same river twice' refers to the material aspect of the river (that its material, the river water, is in constant flux)- this of course begs the question of what it is that is constant, when we refer to the river.

The ideas are difficult because expressed in the form of aphorisms, such as "All things come out of the one, and the one out of all things"; or as paraphrased by Plato, "nothing ever is, everything is becoming". The basic point, however, raised by Heraclitus, is to explain how there can be a fundamental and unchanging stuff if we have no evidence for it, since all we see is in flux. For Heraclitus, even souls were in flux- they were like Fire, and he remarked that it was 'death to Souls to become water'.

The most important immediate result of Heraclitus's work was its influence on Plato, leading him to the conclusion that 'particulars' (ie., particular instances of things, like a particular river) were not only not knowable, but not even *real*. Aristotle later denigrated Heraclitus for his sloppy arguments. Nevertheless, the few fragments of Heraclitus we possess have been very influential, and their ideas have an interesting similarity to modern ideas in physics about

thermodynamics.

(3) Eleatic School: an Unchanging Reality

(a) **PARMENIDES** (c. 515-445 BC): Our knowledge of Parmenides is derived mainly from (i) the discussion of his ideas by Plato, notably in the dialogues *Parmenides*, *Theaetetus*, and the *Sophist*; and (ii) from the fragments of a short book he wrote in verse (usually called "*On Nature*"). Later pre-Socratics also referred often to his ideas. The meeting between an old Parmenides (roughly 65), Zeno (roughly 40), and a very young Socrates, described by Plato, took place around 450 BC.

The poem of Parmenides is a remarkable work. It describes a journey to the home of a goddess, the goddess Justice, taken in a chariot- the journey is begun in darkness and ends in light, escorted by the Sun Maidens (daughters of the Sun) from the Halls of night into the daylight, until they come to a gate which the goddess opens, escorting him in, where she tells him that he was right to come, and that here he will learn 'the unshakeable heart of well-rounded truth, and the beliefs of mortals, in which there is no true reliability'.

The goddess reveals to him 3 ways to truth- telling him that 2 of these are false, and that only the 1st of the 3 is correct. The 2nd way is described as "that *it* is not, and must necessarily not be- this I tell you is a way of total ignorance". The idea is that it is impossible to know something that does not exist- *something* must either exist or not, and therefore *it* must exist. The 3rd way is described by "to be and not to be is the same and not the same". This way is followed by mortals, who treat existence and non-existence in the same way. They suppose there is change (ie., that things can pass from existence to non-existence), and that there are differences between things (that some things contain less or more of 'being' or existence than others). The 1st and true way is then revealed- that "*it* exist and must exist", ie., that reality (the '*it*') is ungenerated and indestructible (must always exist), and that no distinctions can be made within it (no 'degrees of being, it is everywhere the same). So there is no beginning in space and time, and what exists is single, indivisible, homogeneous, and eternal. There is no motion or change- which would imply destruction of one thing for another, and hence non-existence. This what exists remains the same, "held fast in the bonds of limit by Necessity". Parmenides then makes the analogy of a perfect sphere- this seems to be an attempt to portray an isotropic, homogeneous universe. The rest of the poem deals with what is revealed by the 3rd way of mortals- this is essentially a descriptive and constructive phenomenology of the world- it is not clear why it is in the poem, since it is held to be illusory.

The whole story has heroic overtones, reminiscent of Homer, and of the journey of Odysseus down to Hades. One is also reminded of the idea of a dream in which truth is revealed. Yet Parmenides did not mean to be mystical- he recounts how the goddess enjoins him to 'use his reason to judge her words'. This is strong stuff for a Greek living at this time.

The important argument for us is that leading to the idea that the universe is "One", an indivisible and infinite which is present everywhere. The basic Metaphysical argument is that anything that can be thought of must exist- that the objects of all our ideas must be real. Moreover, since we can think of them at any time, they must always exist. It is nonsensical to suppose that "nothing" could exist. This then leads to the conclusion that there can be no void anywhere, that all of space must be filled, that there can be no change (since this would involve objects coming and going) and that one thing cannot change into another. Thus change must be illusory.

The importance of all of this lies in the argumentation- an attempt to derive general properties of the world through logical argument. Nowadays we might wish to call into question the attempt to extrapolate from the structure of language to statements about the nature of the world. The mere fact that we can think of something is not perhaps a good argument for its existence, and we are now rightfully suspicious of any attempt to derive statements about the world through purely metaphysical arguments. However the arguments of Parmenides still have great force in the metaphysical realm, once one starts discussing, eg., the ultimate nature of 'reality'.

(b) **ZENO of ELEA** (born c. 490 BC); It is believed that Zeno produced his work in a single book, sometime around 460 BC. He produced a number of notorious arguments, both metaphysical and semi-mathematical, which are still discussed today. At the time Zeno's main goal was to both to extend the arguments of Parmenides, and to attack the arguments of the 'pluralists' (see below), who were contemporaries of his, and who tried to deny the main thesis of Parmenides. His famous arguments and paradoxes were presented in dialectic form- this appears to be the first use of this style of argument.

Zeno's Arguments against pluralism: There are a number of these, and although the basic idea behind all of them is very similar, it is worth repeating several of them:

(i) *1st argument- divisibility 1:* This argument begins by pointing out that if an object is divisible into parts, each of which is a 'unity' (ie., no longer further divisible), then each part must have zero size- otherwise it would be further

divisible. Moreover there will be an infinity of these parts (we would now think of these as mathematical points). But he then goes on to point out that such parts, when added together, would still yield zero size- adding nothing to nothing gives nothing. So they must have some size- however, if they do have size, then adding them together then gives an object of infinite size. The conclusion of this argument is that reality cannot be divisible, and must be one.

(ii) *2nd argument- number of existents*: Zeno argues first that if the world is divided into some definite number of parts, then this number must be a finite number. But he then goes on to argue that in this case, one can always find numbers (ie., parts) in between the original ones. But this process can be continued *ad infinitum*- therefore, the number must be infinite. Again, this is an argument for the One.

(iii) *3rd argument- divisibility 2*: This argument, which is repeated by Aristotle (the original has been lost), is very similar to the first. It says that if an 'existent' is infinitely divisible, then it can be divided exhaustively (ie., as far as possible); and this must give parts of zero extension. But then again, the argument goes, no finite object can be constructed by adding together parts of zero extension.

Zeno's Arguments against motion: These are the most famous- they survive today in elementary schools and in nursery tales, as well as in serious mathematical discussion. They are all arguments designed to show that motion is impossible, ie., that existence must be unchanging.

(i) *1st argument- The Race Course*: According to this argument, a runner in a race can never finish it. Zeno notes first that the course can be infinitely divided (using, eg., the argument for the infinite number of existents given above). However this means that the runner must pass between an infinite number of different positions to get to the end- and this is impossible, since an infinite sequence of acts in a finite time is impossible. So the race can never finish.

(ii) *2nd argument- Achilles and the Tortoise*: This argument is similar to the first one- however it imagines a very fast Achilles starting, eg., 100 metres from the finish, racing against a tortoise which starts 1 metre from the finish. The construction assumes that Achilles runs 100 times faster than the tortoise. Then Zeno breaks up the race into an infinity of steps. The first step brings Achilles to where the tortoise started- at which time the tortoise is now only 1 cm from the finish. The 2nd step brings Achilles to this point- at which time the tortoise is now only 0.1 mm from the finish. It is easy to see that one can continue this process *ad infinitum*, each time reducing the distance to the finish by a factor of 100. Then says, Zeno, this process can never finish. In modern form for children, this is sometimes called the race between the Hare and the Tortoise (the form devised in Aesop's fables).

(iii) *3rd argument- The Arrow*: In this argument, Zeno begins by arguing that at any given instant, an arrow must occupy a definite place, and no other, and that therefore it had to be considered as being at rest. But this argument, according to Zeno, is true even for a moving arrow- therefore a moving arrow must be at rest. Again, this is taken to mean that motion is impossible.

There are a number of other arguments of this sort attributed to Zeno (eg., the 'millet seed' argument, the 'moving blocks' argument, or the 'Argument against place', all of which are recounted by Aristotle). From a modern perspective all of them are concerned with infinitesimals and with infinite sets. Some of them are very subtle, hence the continued interest in them; others have rather obvious flaws. From a historical standpoint, their main importance was threefold. First, they influenced the Atomists (see below) and Aristotle (section 1.6), particularly in forcing them to see the problems associated with spatial extension. Second, they introduced a very important new style of argument in intellectual discourse, in which a logical argument is developed by developing a thesis, looking at arguments for and against it, making logical inferences, and arriving eventually at a logical conclusion. This style had a huge influence on all subsequent philosophy and mathematics, and its development was widely attributed to Zeno (eg., by Aristotle). Finally, Zeno's arguments and the style of their development, in which one tried to develop a logical proof for an assertion, had a large influence on the development of mathematics- particularly on what we now call number theory, and on axiomatic geometry.

(4) The Pluralists- Elements

(a) **EMPEDOCLES** (c. 490-430 BC): Empedocles was a Sicilian- his philosophical approach had the merit of being the first to posit a number of different fundamental kinds of matter or 'stuff'. This was the first theory to involve what we now call 'elements'. His ideas are known from 2 poems, one entitled "On the Nature of Things", and the other "Purifications"; the latter was more religious in nature. In his theory of the world, Empedocles apparently proceeded from the observations that (i) one could put, eg., water and air together without them mixing (NB- not entirely true- air dissolves in water!), and (ii) one had somehow to explain how one could get so many different materials and forms (often by mixing them). The natural hypothesis was that there were several elements. The choice of fire, water, earth, and air was presumably made on the basis of observations of different changes taking place.

These 4 elements are, in line with previous ideas, held to be eternal, indestructible, and ungenerated (ie., without

beginning and end in time); all changes in Nature come from the mixing or separation of these 4 elements. Thus all the more complex phenomena we see (mountains, stars, trees, people, etc., are not in themselves 'real', but merely ephemeral combinations of the 4 elements. Apparently Empedocles accepted the Eleatic arguments for the impossibility of empty space, but felt that movement was still possible- this happened by the interchange of different elements or mixtures between different parts of space.

There remained the question of what drives or motivates the various changes that are constantly occurring in the world. Here Empedocles showed a somewhat more mystical side, arguing that there were 2 basic principles in operation- these being called Love and Strife. Love was ultimately responsible for bringing elements together, whereas Strife tended to force them apart. The interesting thing here is that Empedocles in no way thought of these motivating causes or principles as abstract or inanimate- nor were they purely mechanical in their actions. Indeed, in this poem on "Purifications", they acquire a moral dimension- strife is evil and Love is good, and the universe is constantly moving from a stage where Love is predominant, to one where Strife holds sway. Empedocles was an optimist- he felt that at his time, Love was on the ascendant, and that humans had in fact fallen from a previously blessed state in which our souls were at one with each other. This fall was caused by strife, principally the sin of eating animals (it is not known whether Empedocles was a vegetarian!). Empedocles even apparently thought that humans needed to find Love again by going through a series of reincarnations, divesting themselves of Strife and seeking at least parts of Love, unadulterated by Strife. In his other writings on human physiology and human nature, Empedocles gave a medical turn to his philosophy - some of his speculations are quite fascinating, but we have no space for them here.

Empedocles was one of the most interesting of the Greek philosophers, and his ideas were extremely influential. Both Plato and Aristotle accepted the idea of 4 elements, and the principle of Love and Strife - indeed these ideas have held their grip on the Western imagination ever since. His spiritual blend of cosmogony and the reincarnation of human souls, via a striving towards Love, was also strongly influential, and found its way into later religious canons, along with the later ideas of Plato and Aristotle.

(b) **ANAXAGORAS** (C. 500-428 BC): Unfortunately not enough is known about Anaxagoras- even the time at which he lived is controversial. He was a well-known personality in Athens at the time of Pericles, and indeed part of the circle of writers associated with him- he also had some influence on Euripides. Only one work of his is known, almost entirely through fragments and commentaries on it provided by Aristotle and Simplicius. It appears that perhaps around 450 BC he was ejected from Athens for his atheism and/or impiety, and died in exile some time later.

The philosophy of Anaxagoras had none of the religious overtones of that of either the Eleatics or the pluralists- in this respect it had more affinity with the older Milesians. The 2 distinguishing features of his philosophy that we know of are (i) the introduction of an entirely non-material 'first cause' of all motion and change in the world, which he identified with 'Mind'; and (ii) a form of pluralism in which all objects in the world contained elements of all others, in greater or lesser proportion.

The first step is important, in that it introduces Mind as a separate entity, and separates it entirely from the physical world. In his approach, Mind is the initiating cause of the world and its structure, and is still the cause of the actions of all living things- but it is entirely absent now from the material world, except for its presence in living things. In the beginning of the world, Mind was responsible for initiating, in the primeval undifferentiated mass, a vortex-like rotational movement which began to separate out different parts of the mass, creating the extremely inhomogeneous result we now see. However all the different things we see today were supposed to be initially present - in particular, organic elements like hair, or skin, are now everywhere present to some degree, but we are only aware of them in the hair or skin we see because they are elsewhere in very small concentrations. Thus quite generally, every material we see contains some fraction of every other (the total number of the different kinds of material is left undetermined!). This rather peculiar theory was apparently inspired in some part by Anaxagoras's observations of living things- notably the transformation of the things we ingest (food, drink) into living tissue.

Anaxagoras was unimpressed by Zeno's objections to plurality- remarking that "of the small, there is no smallest", i.e., that things (including number) were infinitely divisible. It is hard at first glance to see why his ideas led to his exile from Athens- apparently the chief crime was to assert that the sun was merely a burning rock "larger than the Peloponnese", rather than being a divine being. Subsequent thinkers were most influenced by his idea of Mind as a prime mover - this step had a large impact on Western thought and religion.

(5) The Atomists

Atomists like Democritus and Leucippus before him did a number of things (eg., Democritus made some mathematical discoveries) but the idea for which they are most important is that of atoms. Briefly, this philosophy argues that the world was made of atoms, which moved in empty space. There were apparently an infinite number of them, which differed in size and shape (although this argument is not completely clear). They were physically indivisible

(but, apparently, not geometrically indivisible- this is the part that is unclear). They were also indestructible and unchanging. They moved but it is not clear if the Greeks made the connection to heat (certainly Aristotle did not, since he felt that different atoms were at different temperatures according to their shape). Whether they had weight is unclear in the original theory (Aristotle gave them this as well); apparently Democritus said that there was no up or down in the void, comparing the motion of atoms to that of dust in a sunbeam.

Interestingly, collections of atoms were supposed to interact via collisions, and their collective motion could form vortices. It is clear that the Atomists must have had a sophisticated idea of how one could build up complex structures using collections of atoms, including crystalline solids. They believed that thought and perception are both mechanical processes involving atomic motions. Moreover qualities like colour, warmth, etc., were not intrinsic properties of objects but depended also on our sense perceptions; whereas apparently hardness, weight, etc., depended on how the atoms were arranged, ie., on the atoms themselves.

This theory is quite remarkable for several reasons. There were obvious problems for other philosophers- in its attempt to bridge the gap between plural theories like those of Empedocles and the monism of Parmenides, they offended everyone, by substituting an idea which contradicted all of the others, and did not apparently answer any of the questions raised by them. Their answer to the problem of apparent change was to introduce a void, which Parmenides had specifically denied, for reasons given above. However the theory was able to explain many details of the behaviour of the surrounding world. It had another interesting feature- it was deterministic and seemed not to require any kind of motivating force or "cause" to (eg., Love + Strife) to drive things along. This led to the criticism that it did not explain why things happened. That a more limited "mechanical" explanation could be given of details did not impress those like Aristotle and Plato who felt that they could get to the problem of ultimate causes. The ideas of Aristotle later led western thought down a 1500 year path which attempted to find teleological explanations for the world. There is no doubt that Greek religion and mysticism played a role in this, just as the later influence of the Catholic and other Christian dogmas also sought teleological rather than mechanical explanations.

Democritus et al were surely aware of this defect (the lack of an explanation of "initial causes" or any other kind of cause). But they had found a new way of inquiry- to look for explanation of the details in a *hypothesis* about the structure of the world of appearances. And the style of inquiry was crucial- pursue the hypothesis IN SPITE OF the obvious philosophical problems (eg, the presence of a void), to see how far one could get. Thus they attempted a more limited goal than that of ultimate truth- their goal was an explanation of the processes in the sensible world around them. From a modern point of view the accuracy of some of their conclusions, even in the details, was quite incredible, and shows that the Greeks were not prevented from arriving at these by any limitations on the experimental methods or tools available to them. Interestingly, Democritus was a thorough-going sceptic when it came to popular religion, and was not convinced of any underlying purpose in the universe.