

# Pre-Socratic Greek Philosophy

By Thomas Knierim

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## Introduction

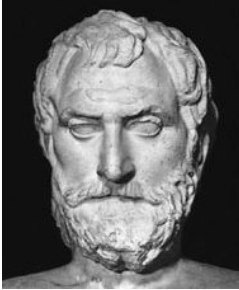
Astonishing advances in art, science and philosophy were made in the eastern part of the Mediterranean Sea about 2,500 years ago. Greek philosophers were among the first in the West to explore nature in a rational way and to make educated guesses about the creation of the world and the universe. This is why Greece is often referred to as the birthplace of Western culture.

Some of the ancient philosopher's speculations have successfully anticipated findings of 20th century science. The concept of atoms, for example, was first formulated by Leucippus and Democritus around 400 BC. Greek thought and values have been extremely influential throughout centuries and lasted until the present day.

The ancient Greeks viewed the world in a way that one would today perhaps describe as "holistic". Science, philosophy and politics were interwoven and combined into one worldview. Moreover, those who look carefully will find subtle, but intelligible parallels between early Greek philosophy and Eastern thought. The Heraclitean fire resembles Buddhist impermanence, while the Greek logos resembles the way of the Tao, just to name two examples. More detailed portraits of Greek ideas and their contenders can be found on the following pages, so read on and find out more about them.

# Thales

[Miletus, 624-546 BC]



Western philosophy begins in the antiquity roughly at the time when historians and poets began recording history. This is of course no surprise. Even if earlier philosophers have existed, their ideas would have been invariably lost if there was no one to write them down. Historiography supposedly started with the Babylonians, before the Greek civilisation, but we shall leave this question to the historians and continue with philosophy.

Try to picture the early Greek civilisation around 600 BC. Imagine yourself in a flourishing commercial town at the sunny coast of Ionia. The Greeks traded intensively with each other and with surrounding nations. Many Greek city states accumulated considerable wealth and with it came art, science and philosophy. However, there was trouble.

The political climate was afflicting. As a consequence of slavery, mercantilism and political conflict there was much turmoil. Greek cities were often ruled by ruthless tyrants, landowning aristocrats and rich merchants, who gave little importance to ethical considerations. Around the beginning of the 6th century BC, there lived a man in Miletus whose name was Thales, one of the Seven Wise Men of Greece. He was the son of an illustrious Milesian family; his father was Examydes and his mother was Cleobulina who came from a noble Phoenician family.

Thales had travelled to Egypt to study the science of geometry. Somehow he must have refined the Egyptian methods. When he came back to Miletus, he surprised his contemporaries with his unusual mathematical abilities. He calculated the distance of a ship at sea from observations taken on two points on land. He knew how to determine the height of a pyramid from the length of its shadow. What sealed his fame was the prediction of a solar eclipse in 585 BC.

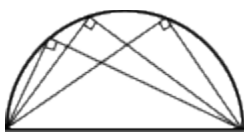
In spite of his wisdom and his family's fame, Thales was a poor man. The inhabitants of Miletus ridiculed him for his philosophy and asked him what his wisdom is good for if it can't pay the rent.

"He was reproached for his poverty, which was supposed to show that philosophy is of no use. According to the story, he knew by his skills in the stars while it was yet winter that there would be a great harvest of olives in the coming year; so, having a little money, he gave deposits for the use of all olive-presses in Chios and Miletus, which he hired at a low price because no one bid against him.

When the harvest time came, and many were wanted all at once and of a sudden, he let them out at any rate which he pleased, and made a quantity of money. Thus he showed the world that philosophers can be rich if they like, but that their ambition is of another sort.” (from Politics, Aristotle)

At other times, Thales proved himself a foresighted statesman: “Useful advice had been given, even before the destruction of Ionia by Thales, a Milesian whose family originally came from Phoenicia. He urged the Ionians to establish a single council chamber, saying that it should be located in Teos, which was at the centre of Ionia, and that other cities should continue to be inhabited, but should be treated as though they were parishes.” (Herodotus, Histories I) Thales wanted to strengthen Ionia against Lydia. His exhortations availed little, since in 560 BC Ionia came under the rule of Croesus, the last king of Lydia.

Thales was also a mathematician and a universal scholar, but in antiquity there existed no classification of the natural sciences and philosophy as today; instead, mathematics, philosophy and science were closely related in the works of the early Greek philosophers. Unfortunately only fragments of the teachings and findings of Thales have survived. According to other philosophers, he has produced two works named On the Solstice, and On the Equinox, but we don’t know this for certain. His works –if he wrote any at all– had already been lost only 300 years later at the time of Aristotle.



Most people remember Thales for his famous proposition about right angles: a triangle inscribed in a semicircle has a right angle (see figure on the left). Although this may seem a simple observation, Thales was the first one who stated it and thus started what is now known as “deductive science”, the process of deriving propositions and mathematical theorems from observation by means of logic.

According to Proclus, he also found the following theorem: “He is said to have been the first to have recognised and stated, that in every isosceles triangle the angles at the base are equal.” (Commentary on Euclid, Proclus) Circles and angles were not the only objects Thales was concerned with. Purportedly he also studied magnetism and electrostatic effects. However, since none of his works have survived, we don’t know what he may have found out about them. Thales seemed to have believed that magnets have a soul, because he saw the soul as the principle of motion.

Thales was without doubt an exceptional man, but he was not the only thinker in ancient Greece whose thoughts were ahead of his time. For instance, the idea that all forms of substances can be reduced to a few elements and that every form of matter are made of these elements, is characteristically Greek, and it was conceived around the time of

Thales. A perpetual debate arose between Thales and other philosophers about which element constitutes the original substance.

Thales stated that the origin of all matter (arché) is water. Although this sounds a bit odd from the perspective of modern science, there is some truth in it. We know that the largest constituent of the universe is hydrogen, which makes up two of the three atoms in water (H<sub>2</sub>O). The missing oxygen atom was added when our planet formed. Moreover, scientists believe that liquid water is prerequisite to life. Since life on Earth began in the oceans, water is indeed the primordial substance par excellence. Thales also believed that the Earth rests on water, like a barrel that swims in the sea. He held that the Earth moves and rolls like a ship when people observe earthquakes.

You may find these ideas strange, but it has to be considered that the early Greek philosophers lived in an environment where indigenous beliefs and superstitions prevailed in the spiritual world and the rule of thumb was accepted authority. Thales was one of the first who rejected the traditional explanations of the world's origin. Instead of building on the myopic ideas of mythology, he began a rational inquiry into the riddles that nature presents. This inquiry is based on reflection and reason alone, and it may be his greatest achievement. Aristotle wrote in *Metaphysics*:

“Of the first philosophers, then, most thought the principles which were of the nature of matter were the only principles of all things. That of which all things that are consist, the first from which they come to be, the last into which they are resolved (the substance remaining, but changing in its modifications), this they say is the element and this the principle of things, and therefore they think nothing is either generated or destroyed, since this sort of entity is always conserved. [...] Yet they do not all agree as to the number and the nature of these principles. Thales, the founder of this type of philosophy, says the principle is water.”

There are two eminent characteristics of the theories of Thales and his successors: (1) they are perfectly naturalistic, which means they try to explain the world in a common sense fashion without invoking supernatural powers, (2) they are predominantly non-dualistic, either by sidestepping the separation between matter and mind, or by reducing the latter to the former.

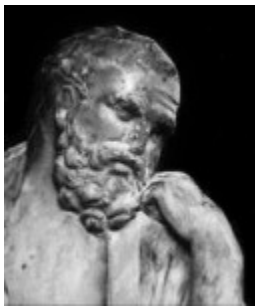
There are a number of aphorisms ascribed to Thales. “He said that ‘death is no different from life’. ‘Then why don’t you die?’ someone asked him. ‘Because it makes no difference,’ he replied. When someone asked him which came first, day or night, he answered, ‘Night came first – by a day.’ [...] How can we live best and most justly? – If we do not ourselves do the things we blame others for doing. Who is happy? One who has a healthy body, a well-stocked soul and an educable nature. He says that we should remember our friends both present and absent, and that we should not beautify our faces but be beautiful in our

practices. ‘Do not be rich by evil means,’ he said, ‘and let not words estrange you from those who have shared your trust.’” (Diogenes Laertius, *Lives of the Philosophers* I)

It is said that Thales remained unmarried for all of his life. When his mother pressed him to marry, he said, “It is too early,” and when he had passed his prime and his mother insisted again, he said, “It is too late.” When he was asked why he had no children, he would reply, “Because I love children.” Thales died of heat, thirst and weakness when he was watching a gymnastic contest. He was almost 80 years old then. I would like to end this Thales portrait with a peculiar quote, which shows the spiritual Thales. He said: “All things are full of gods,” and left it unexplained.

## Anaximander

[Miletus, 610 - 546 BC]



Anaximander like Thales came from Miletus. While our knowledge of Thales is based on uncertain historical accounts, we are in a better position with Anaximander. The later doxographers, including Aristotle, Plato and Theophrastus, had access to Anaximander’s original writings and there are plenty of details reported about his ideas, although not much is known about his life. It is very likely that Anaximander was a pupil of Thales. In particular, the treatment of cosmology and ontology –which were Anaximander’s principal studies– shows congeniality with Thales.

Anaximander made bold inquiries; he questioned the myths, the knowledge of the old, the heavens, and even the gods themselves. He was wholly rational in his approach and his quest was to derive natural explanations for phenomena that previously had been ascribed to the agency of supernatural powers. Meteorology is a perfect example for this.

Anaximander explained the wind as the fine and moist effluvium of air massing together and set in motion by the sun. He explained rain as coming from vapour sent up by the things beneath the sun. He also explained lighting and thunder and he affirmed that it is not Zeus who throws thunderbolts down upon the Earth, but that these phenomena have natural causes. According to Anaximander, they are caused by pneuma, or compressed air, which builds up inside thick clouds, until it breaks out. The forceful parting of the cloud then causes thunder and lightning.

His account of meteorology constitutes a most innovative proposition. Though only partially correct, it is the first recorded attempt of a scientific explanation of the weather in the history of mankind. But Anaximander did not stop there. He also founded the sciences of geography and astronomy. Moreover, he was the first man in Greece who drew

a map of the known world, which was later refined by travellers and other scholars. This map places Ionia at the centre of the world. To the East it reaches to the Caspian sea, to the West it ends at the Pillars of Hercules (the rocks of Gibraltar and Mount Hacho in Morocco). In the North we see the landmass of Middle Europe and in the South lies Ethiopia and the lower Nile.



As if charting the known world wasn't enough, Anaximander began to chart the cosmos as well. This was beyond his understanding, as we shall see, but it constitutes one of the first attempts in the Western world of creating a speculative scientific model of the cosmos. Anaximander started by building a spherical model of the world, the planets, and the stars in which the planets lie behind one another. As a rationalist he did this on basis of geometry and mathematical calculations rather than by drawing on

mythological accounts. He attempted to determine the distance of the planets from Earth as well as their size. The circle of the sun is –according to Anaximander– 27 times as big as that of the Earth and the moon's circle is 19 times as big. He assumed that the moon shines its own light like the sun.

He further proposed that the sun and the stars are fires trapped in globular masses by cooler air. These fires appear to us not directly, but through vents a bit like that of a trumpet or a gramophone. "The heavenly bodies come into being as a circle of fire, separated off from the fire in the world and enclosed by air. There are certain tubular channels or breathing holes through which the heavenly bodies appear; hence eclipses occur when the breathing holes are blocked, and the moon appears sometimes waxing and sometimes waning according to whether the channels are blocked or open." (Hippolytus, *Refutation of All Heresies I*)

Anaximander believed that the Earth is cylindrical in shape, its diameter being three times its height, and that we are sitting on its flat circular surface on top of it. He held that the Earth is aloft, not supported by anything. Apparently he concluded this from the assumption that the heavenly bodies describe full circles around the Earth. He explained that it stays in that position, because it is at equal distance from all other heavenly bodies and thus does not move in any particular direction. The Earth is therefore in a state of balance and needs no support. This idea was fundamentally new. It contains –in its beginnings– the idea of gravitation. Anaximander's account of the creation of the universe is likewise innovative:

"Anaximander maintains that the eternally productive cycles of hot and cold separated off in the generation of this world and formed a spherical shell of fire surrounding the Earth

and its atmosphere like the bark around a tree. When this sheath of fire finally tore up and divided into various wheel-shaped stripes, the sun, moon and the stars were created from it.” (Pseudo Plutarch, Stromateis 2)

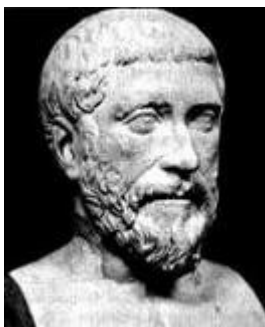
While there were many unique aspects in Anaximander’s meteorology, geography and cosmology, what he is ultimately known for is his theory of the *apeiron*. The *apeiron* is the *Boundless* or the *Infinite*. Anaximander held that the universe is boundless and that the number of worlds in it is infinite. Thus the argument develops from the physical model of the cosmos and carries on the idea of cosmic balance into a striking metaphysical argument.

The *apeiron* is not plainly spatiotemporal infinity, but the principle and the origin (Greek: *archê*) of existence itself. Since very little of Anaximander’s own words have survived, we have to turn to Aristotle for a description of the *apeiron*: “Everything has an origin or is an origin. The Boundless has no origin. For then it would have a limit. Moreover, it is both unborn and immortal, being a kind of origin. For that which has become has also, necessarily, an end, and there is a termination to every process of destruction.” (Aristotle, Physics 203b6-10).

The *apeiron* is thus the quintessential primordial ground from which everything arises. Although we don't know whether Anaximander defined the *apeiron* in any precise manner, it was imagined as kind of primal chaos, a formless and limitless mass, from which solid matter forms and to which it returns. In Anaximander’s own words: “Whence things have their origin, thence also their destruction happens, as is the order of things; for they execute the sentence upon one another - the condemnation for the crime - in conformity with the ordinance of time.” (Simplicius)

## Pythagoras

[Samos, 582 - 500 BC]



Like Thales, Pythagoras is rather known for mathematics than for philosophy. Anyone who can recall math classes will remember the first lessons of plane geometry that usually start with the Pythagorean theorem about right-angled triangles:  $a^2+b^2=c^2$ . In spite of its name, the Pythagorean theorem was not discovered by Pythagoras. The earliest known formulation of the theorem was written down by the Indian mathematician Baudhāyana in 800BC. The principle was also known to the earlier Egyptian and the Babylonian master builders. However, Pythagoras may have proved the theorem and



popularised it in the Greek world. With it, his name and his philosophy have survived the turbulences of history.

His immediate followers were strongly influenced by him, and even until today Pythagoras shines through the mist of ages as one of the brightest figures of early Greek antiquity. The Pythagorean theorem is often cited as the beginning of mathematics in Western culture, and ever since mathematics -the art of demonstrative and deductive reasoning- has had a profound influence on Western philosophy, which can be observed down to Russell and Wittgenstein.

Pythagoras' influence found an expression in visual art and music as well, particularly in the renaissance and baroque epoch. The far-reaching imprint of his ideas is yet more impressive if we consider that he did not leave any original writings. Instead, all what is known about Pythagoras was handed down by generations of philosophers and historiographers, some of whom, like Heraclitus, opposed his views. In this light it is remarkable that Pythagoras' teachings have survived relatively undistorted until the present day.

Pythagoras was a native of the island of Samos. During his early life, Samos was governed by the powerful, unscrupulous tyrant Polycrates. Pythagoras did not sympathise with his government and thus emigrated to Croton in Southern Italy. Like the ancient Greek cities in Ionia, Croton was a flourishing commercial city that lived from importing and exporting goods. Obviously it was in Croton where Pythagoras developed most of his important ideas and theories.

Pythagoras founded a society of disciples which has been very influential for some time. Men and women in the society were treated equally -an unusual thing at the time- and all property was held in common. Members of the society practised the master's teachings, a religion the tenets of which included the transmigration of souls and the sinfulness of eating beans. Pythagoras' followers had to obey strict religious orders where it was forbidden to eat beans, to touch white cocks, or to look into a mirror beside a light.

If all of this seems a bit odd, it might lead us to suspect that Pythagoras' personality reflects the inseparable blend of genius and madness that we associate with many other great men. It is said that once Pythagoras was walking up a lane in Croton when he came by a dog being ill-treated. Seeing this he raised his voice: "Stop, don't hit it! It is a soul of a friend. I knew it when I heard its voice." Spirits, ghosts, souls, and transmigration were obviously things he believed in deeply.

There was an opposition -if not rivalry- in ancient Greece between the gods of the Olympus and the lesser gods of more primitive religions. Pythagoras, like no other, embodied the contradistinctions of the mystical and rational world, which is woven into



his personality and philosophy. In his mind, numbers, spirits, souls, gods and the mystic connections between them formed one big picture. The following text tells the legend of his own existences:

“He was once born as Aethalides and was considered to be the son of Hermes. Hermes invited him to choose whatever he wanted, except immortality; so he asked that, alive and dead, he should remember what happened to him. Thus, in life he remembered everything, and when he died he retained the same memories. [...] He remembered everything - how he first had been Aethalides, then Euphorbus, then Hermotimus, then Pyrrhus, the Delian fisherman. When Pyrrhus died, he became Pythagoras.” (Diogenes Laertius, *Live of Philosophers*, VIII 4-5)

“Pythagoras believed in metempsychosis and thought that eating meat was an abominable thing, saying that the souls of all animals enter different animals after death. He himself used to say that he remembered being, in Trojan times, Euphorbus, Panthus’ son who was killed by Menelaus. They say that once when he was staying at Argos he saw a shield from the spoils of Troy nailed up, and burst into tears. When the Argives asked him the reason for his emotion, he said that he himself had borne that shield at Troy when he was Euphorbus.

They did not believe him and judged him to be mad, but he said he would provide a true sign that it was indeed the case: on the inside of the shield there had been inscribed in archaic lettering EUPHORBUS. Because of the extraordinary nature of his claim they all urged that the shield be taken down - and it turned out that on the inside the inscription was found.” (Diogenes Laertius)

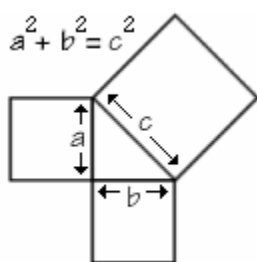
After Pythagoras introduced the idea of eternal recurrence into Greek thought, which was apparently motivated by his studies of earlier Egyptian scriptures, the idea soon became popular in Greece. It was Pythagoras’ ambition to reveal in his philosophy the validity and structure of a higher order, the basis of the divine order, for which souls return in a constant cycle.

This is how Pythagoras came to mathematics. It could be said that Pythagoras saw the study of mathematics as a purifier of the soul, just like he considered music as purifying. Pythagoras and his disciples connected music with mathematics and found that intervals between notes can be expressed in numerical terms. They discovered that the length of strings of a musical instrument correspond to these intervals and that they can be expressed in numbers. The ratio of the length of two strings with which two tones of an octave step are produced is 2:1.

Music was not the only field that Pythagoras considered worthy of study, in fact he saw numbers in everything. He was convinced that the divine principles of the universe,

though imperceptible to the senses, can be expressed in terms of relationships of numbers. He therefore reasoned that the secrets of the cosmos are revealed by pure thought, through deduction and analytic reflection on the perceptible world.

This eventually led to the famous saying that “all things are numbers.” Pythagoras himself spoke of square numbers and cubic numbers, and we still use these terms, but he also spoke of oblong, triangular, and spherical numbers. He associated numbers with form, relating arithmetic to geometry. His greatest contribution, the proposition about right-angled triangles, sprang from this line of thought:



“The Egyptians had known that a triangle whose sides are 3, 4, 5 has a right angle, but apparently the Greeks were the first to observe that  $3^2 + 4^2 = 5^2$ , and, acting on this suggestion, to discover a proof of the general proposition. Unfortunately for Pythagoras this theorem led at once to the discovery of incommensurables, which appeared to disprove his whole philosophy. In a right-angled isosceles triangle, the square on the hypotenuse is double of the square on either side.

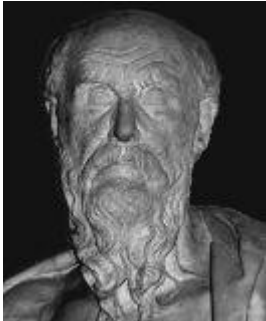
Let us suppose each side is an inch long; then how long is the hypotenuse? Let us suppose its length is  $m/n$  inches. Then  $m^2/n^2 = 2$ . If  $m$  and  $n$  have a common factor, divide it out, then either  $m$  or  $n$  must be odd. Now  $m^2 = 2n^2$ , therefore  $m^2$  is even, therefore  $m$  is even, therefore  $n$  is odd. Suppose  $m = 2p$ . Then  $4p^2 = 2n^2$ , therefore  $n^2 = 2p^2$  and therefore  $n$  is even, contra hyp. Therefore no fraction  $m/n$  will measure the hypotenuse. The above proof is substantially that in Euclid, Book X.” (Bertrand Russell, History of Western Philosophy)

This shows how Pythagoras’ formulation immediately led to a new mathematical problem, namely that of incommensurables. At his time the concept of irrational numbers was not known and it is uncertain how Pythagoras dealt with the problem. We may surmise that he was not too concerned about it. His religion, in absence of theological explanations, had found a way to blend the “mystery of the divine” with common-sense rational thought.

From Pythagoras we observe that an answer to a problem in science may give raise to new questions. For each door we open, we find another closed door behind it. Eventually these doors will be also be opened and reveal answers in a new dimension of thought. A sprawling tree of progressively complex knowledge evolves in such manner. This Hegelian recursion, which is in fact a characteristic of scientific thought, may or may not have been obvious to Pythagoras. In either way he stands at the beginning of it.

# Heraclitus

[Ephesus, around 500 BC]



Heraclitus lived around 500 BC in the city of Ephesus in Ionia, Asia Minor. He became famous as the “flux and fire” philosopher for his proverbial utterance: “All things are flowing.” Coming from an eminent aristocratic family, Heraclitus is the first nobleman in the cabinet of Greek philosophers. He introduced important new perspectives into Greek thought and produced a book of which his followers said that it is hard to read.

“They say that Euripides gave Socrates a copy of Heraclitus’ book and asked him what he thought of it. He replied: “What I understand is splendid; and I think what I don’t understand is so too - but it would take a Delian diver to get to the bottom of it.” (Diogenes Laertius, *Lives of Philosophers*, II 22).

In spite of the difficulties, Heraclitus was admired by his contemporaries for the theory of flux, which influenced many generations of philosophers after him. Judging from his writings, Heraclitus doesn’t appear to be a complaisant character. Not only does he condemn all of his philosophic predecessors, but his contempt for mankind leads him to think that dullness and stupidity are innate human traits.

He repeatedly lets fly at mankind in general and in particular scolds at those who do not share his opinion. Here is a taste of it: “The Ephesians would do well to hang themselves, every grown man of them, and leave the city to the beardless lads; for they have to cast out Hermorodus, the best man among them [...]” There is only Teutamius being saved from despise of whom he says that he is “of more account than the rest.” Investigating the reason for the praise one finds that Teutamius had said that “most men are bad.”

As it might be expected, Heraclitus believed in war. He said: “War is father of all, king of all. Some it makes gods, some it makes men, some it makes slaves, some free.” And: “We must realise that war is universal, and strife is justice, and that all things come into being and pass away through strife.” Now, if this sounds like Nietzsche, it doesn’t come as a surprise, in fact Nietzsche had been a great admirer of Heraclitean philosophy.

Rigid moralism is also found in Heraclitus’ ethics, which may be described as disdainful asceticism. He prays to refrain from alcohol: “A man, when he gets drunk, is lead by a beardless lad, tripping, knowing not where he steps, having his soul moist.” Heraclitus praises the power obtained through self-mastery, and despises the passions that distract men from their chief ambition, self-purification: “It is not good for men to get all that they wish to get. Whatever our desire wishes to get, it purchases at the cost of soul.”

In the end, Heraclitus became a hermit, leaving the city and living in the mountains where he fed on plants and herbs. Because of this he contracted dropsy and was forced to return to the town. He asked the doctors in his riddling fashion if they could change a rainstorm into a draught. When they failed to understand him, he buried himself in a byre, hoping that the dropsy would be vaporised by the heat of the dung. But he met with no success even by this means and died at the age of sixty.

Knowing Heraclitus' personality may help us to put his philosophical theories into the proper light. Let us look at the idea of flux and fire. Before Heraclitus, the world of the ancient Greeks had been fairly static. The Olympic Gods were eternal as the world they were gazing down upon. Everything was firmly embedded into an indivisible universe. The common principles of nature were perceived as everlasting and unchangeable, although what mankind knew about them was certainly limited.

The Greeks before Heraclitus focused on the essence of things, its nature and being, which they deemed unchangeable. In contrast, Heraclitus said: "You cannot step into the same river twice, for fresh waters are ever flowing in upon you." This simple sentence expresses the gist of his philosophy, meaning that the river isn't actually the same at two different points in time. - It is a radical position and Heraclitus was the to conceive it. He looked at everything being in the state of permanent flux and, hence, reality being merely a succession of transitory states. He told people that nothing is the same now as it was before, and thus nothing what is now will be the same tomorrow. With this he planted the idea of impermanence into Greek thought, and indeed, after Heraclitus Greek philosophy was not the same anymore.

Heraclitus held that fire is the primordial element out of which everything else arises. Fire is the origin of all matter; through it things come into being and pass away. Fire itself is the symbol of perpetual change because it transforms a substance into another substance without being a substance itself: "This world, which is the same for all, no one of gods or men has made; but it was ever, is now, and ever shall be eternal fire." and: "Fire lives the death of air, and air lives the death of fire; water lives the death of earth, earth that of water. Measures of it kindling and measures of it going out." (Diogenes Laertius)

Like Anaximander, Heraclitus sees a cosmic balance in the struggle of the elements, water, air, fire, earth. Due to the eternal transmutation of forms, which are made of the elements, no single element ever gains predominance. This implies that Heraclitus thinks of fire as a non-destructive; but merely transforming power. The process of transformation does not happen by chance, but is, according to Heraclitus, the product of God's reason -logos-, which is identical to the cosmic principles.

When Heraclitus speaks of God, he doesn't mean the Greek gods, neither a personal entity. Instead he thinks that God is living in every soul and even in every material thing on earth. The fiery element is the expression of God in everything, thus he is in every sense a pantheist.

Another of Heraclitus' main teachings can be called the "unity of opposites". The unity of opposites means that opposites cannot exist without each other - there is no day without night, no summer without winter, no warm without cold, no good without bad. To put it in his own words: "It is wise to agree that all things are one. In differing it agrees with itself, a backward-turning connection, like that of a bow and a lyre. The path up and down is one the same." Comparing the convergence of opposites with the contrary tension of a bow and a lyre is perfectly in harmony with his theory of flux and fire.

From a modern perspective it seems trivial to state that opposites are the same, yet to the Greek it was not entirely obvious. Hot and cold can both be expressed as a degree of temperature, dark and bright as a degree of light. Nonetheless, the Heraclitean theory of perpetual flux and universal transformation goes far beyond what was obvious to the ancients:

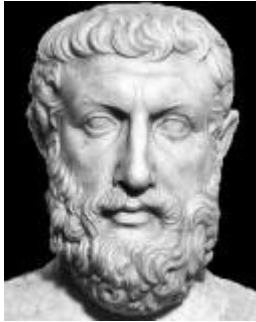
"Science, like philosophy, has sought to escape from the doctrine of perpetual flux by finding some permanent substratum amid changing phenomena. Chemistry seemed to satisfy this desire. It was found that fire, which appears to destroy, only transmutes: elements are recombined, but each atom that existed before combustion still exists when the process is completed.

Accordingly it was supposed that atoms are indestructible, and that all change in the physical world consists merely in rearrangement of persistent elements. This view prevailed until the discovery of radioactivity, when it was found that atoms could disintegrate. Nothing daunted, the physicist invented new and smaller units, called electrons and protons, out of which atoms were composed; and these units were supposed, for a few years, to have the indestructibility formerly attributed to the atoms.

Unfortunately it seemed that protons and electrons could meet and explode, forming, not new matter, but a wave of energy spreading through the universe with the velocity of light. Energy had to replace matter as what is permanent. But energy, unlike matter, is not a refinement of the common-sense notion of a 'thing'; it is merely a characteristic of a physical process. It might be fancifully identified with the Heraclitean fire, but it is the burning, not what burns. 'What burns' has disappeared from modern physics." (Bertrand Russell, *History of Western Philosophy*, 1945)

# Parmenides and Zeno

[Elea, 515 - ? BC]



Heraclitus maintained that everything changes, and since philosophers love to argue, it is perhaps unsurprising that someone stated the exact opposite, namely that nothing ever changes. This view was put forward by Parmenides, son of Pyres who came from Elea, a Greek foundation in southern Italy.

The chronicle describes Parmenides as a nobleman who once established a new law for Elea, which became so popular that all new officials of the city had to swear they will abide by the Parmenidean law before they were inaugurated. Parmenides is also known for the philosophical school he established in his city, the Eleatic school. It is further said that Parmenides and his main disciple, Zeno, once came to Athens for the festival of the Great Panathenaea where they had an encounter with the young Socrates. Although the narrative is uncertain, there is no doubt that Socrates, Plato, and Aristotle were strongly inspired by the Eleatic school.

Parmenides stated that the senses deceive us and, hence, our perception of the world does not reflect the world as it really is. Instead, the real world is something above our apprehension and can only be apprehended through logic. His chief doctrine is that the only true being is “the One” which is indivisible and infinite in time and space. But “the One” is not conceived by Parmenides as we conceive God, neither is it reminiscent of the Hindu “Brahman”. Instead he thinks of it as a material being with infinite extension, which he concludes from logical reasoning.

He argues that the perception of movement and change is an illusion and says that everything that is, has always been and will ever be since it can always be thought and spoken of. The essence of this argument is: If you speak or think of something, the word or thought relates to something that actually exists, that is both thought and language require objects outside themselves, otherwise they would be inconceivable. Parmenides assumes a constant meaning of words and concludes from there that everything always exists and that there is no change, for everything can be thought of at all times.

In fact, he did not express his ideas so straightforwardly. His writings are in awkward hexameters, its contents intermixed with unfathomable symbolism, as in the following example: “The mares that carry me as far as my heart may aspire were my escorts; they had guided me and set me on the celebrated road [...] Only one road, one story is left: that it is. And on this there are signs in plenty, that, being it is unborn and indestructible, whole of one kind and unwavering, and complete. Nor was it, nor will it be, since now it is, all together, one, continuous. [...] That it came from what is not I shall not allow you to say

or think - for it is not sayable or thinkable that it is not.” (Simplicius, Commentary on the Physics, 144.25)

Melissus, an eminent citizen of Samos and admirer of Parmenides produced a book approximately 50 years later, rendering Parmenides’ doctrines in clearer prose. In the following excerpt he explains the canon of infinity and perpetuity of the One: “Since what comes into existence has a beginning, what does not come into existence has no beginning. But what exists has not come into being. [which was deducted before in the text] Therefore it has not got a beginning.

Again, what is destroyed has an end, and if something is indestructible it has no end. Therefore what exists, being indestructible, has no end. But what has neither beginning nor end is in fact infinite. Therefore what exists is infinite. If something is infinite, it is unique. For if there were two things they could not be infinite but would have limits against one another. But what exists is infinite. Therefore there is not a plurality of existents. Therefore what exists is one.” (Simplicius, Commentary on the Physics, 103.13)

The above states the gist of classical monism. It is obvious that Parmenides is wrong, although his deductions are logically correct. The problem lies in the axiom; he assumes that the intelligible word and the things themselves have a common form of existence. Parmenides attempted to build his metaphysics on basis of the logical conclusions derived from this axiom. Although the resulting theory is erroneous, his methodology was a genuine innovation.

Parmenides profoundly influenced later philosophers with this method and possibly supplied the spark for Plato’s theory of ideas. Since Eleatic philosophy grossly contradicts common sense, it is unsurprising that his teachings brought forth critical challenge and ridicule among his contemporaries. It was Parmenides’ brightest disciple, Zeno (some say he was his lover, too), who became the chief defender of his master’s position. Again, the methodology is conclusive argument.

Zeno followed his master’s advise to disarm his adversaries by leading their argument ad absurdum and thus became famous for his paradoxes. That the senses give us no clue to reality but only to appearance was proved by Zeno in the following manner (Zeno speaks to Protagoras, the sophist): “Tell me, Protagoras,’ he said, ‘does one millet-seed - or the ten-thousandth part of a millet-seed make a sound when it falls or not?’ Protagoras said that it did not. ‘But,’ he said, ‘does a bushel of millet-seed make a sound when it falls or not?’

When he replied that a bushel does make a sound, Zeno said: ‘Well, then, isn’t there a ratio between the bushel of a millet-seed and the single seed - or the ten-thousandth part of a single seed?’ He agreed. ‘Well, then,’ said Zeno, ‘will there not be similar ratios



between the sounds? For as the sounders so are the sounds. And if that is the case, then if the bushel of millet-seed makes a sound, the single seed and the ten-thousandth part of a single seed will also make a sound.' That was Zeno's argument." (Simplicius, Commentary on Physics, 1108.14-28)

To evince that motion and change is an illusion, Zeno presented the following paradoxes:

1. The Racecourse. Imagine a racecourse of a given length, say 100m. The runner starts at the beginning of the racecourse and reaches the goal in a given time. In this example of motion, the runner traverses a series of units of distance, foot perhaps. Zeno holds, that each unit of distances can be divided into smaller distances,  $1/2$  foot,  $1/4$  foot,  $1/8$  foot and so on, until at last we have an infinite number of distances. How can the runner traverse an infinite number of distances in a finite amount of time?

2. Achilles and the Tortoise. The swift Achilles and the tortoise hold a race contest. Because Achilles is a sportsman, he gives the tortoise a head start. While the tortoise is already moving towards the goal, Achilles starts and pursues the tortoise. In a few seconds he reaches exactly the point, where the tortoise has been when Achilles started. However, during this time the tortoise has moved forward and it takes Achilles a certain amount of time to make up for this distance. Again, the tortoise has moved on in that time and Achilles needs another, smaller amount of time to make up for it. The distance between Achilles and the tortoise will always be divisible and, as in the case of the racecourse, no point can be reached before the previous point has been reached, thus Achilles can never overtake the tortoise.

3. The Arrow. Does the arrow move when the archer shoots it at the target? If there is a reality of space, the arrow must at all times occupy a particular position in space on its way to the target. But for an arrow to occupy a position in space that is equal to its length is precisely what is meant when one says that the arrow is at rest. Since the arrow must always occupy such a position on its trajectory which is equal to its length, the arrow must be always at rest. Therefore motion is an illusion.

There are more of Zeno's paradoxes; almost all involve dichotomy and the mathematical problem of infinity. Although these paradoxes are confusing, it is quite evident to us that the conclusions derived from them are nonsensical. Yet, this was not obvious to Zeno's contemporaries. In the early beginnings of philosophy, these logical pitfalls presented a major obstacle to progressive thought, and Parmenides maintained a significant influence on Greek thought for some time.

The paradoxes illustrate the sort of problems we encounter in language and logic. Zeno's arguments are fallacious and may be refuted, once the correct premises are applied, yet the correct premises are less than obvious. Therefore, Parmenides and Zeno can be

credited with having demonstrated, contrary to their intention, that logic alone is no sure-fire way to attain meaningful knowledge. They have instead shown that the opposite is occasionally true and that we must beware of logical pitfalls. Philosophical reasoning is only as sound as the premises it rests on.

## Empedocles

[Acragas, 490 - 430 BC]



The Pythagorean influence dominated Greek thought for a long time. Many of Pythagoras' ideas can be found in the work of Empedocles. He was the first philosopher who stated that there are four primordial elements: earth, air, fire and water. This is a somewhat statesman-like compromise between the view of Pythagoras who maintained that water is the primordial substance, Anaximenes who said it is air, and finally Heraclitus who said that fire is the origin of everything. The ingenious combination of these views was Empedocles' major contribution to the dispute about the primordial element, which lasted almost as long as Greek philosophy itself.

Empedocles came from a rich and illustrious family in Acragas at the south coast of Sicily. It is said that his grandfather won a victory in the horse-racing at the Olympic games of 496 BC. He was a politician of Acragas who represented the democratic group and he also worked as a scientist and physician.

Legend tells us that Empedocles worked miracles by magic and by his scientific knowledge thus he was often approached by the citizens of Acragas for oracles. People believed he could control the winds and he had allegedly restored to life a woman who had seemed dead for thirty days. He spoke of himself as a god sometimes and his desire to be godlike made him ending his life by leaping into the crater of the Etna volcano, hoping thereby not to leave any remains of his (mortal) body so that people would think he has returned to the gods.

Like Heraclitus, he wrote his philosophical works in verse. The most important writings are *On Nature* and *Purifications* of which numerous fragments have survived. The original texts are quite enigmatic and difficult to read or translate. We will look at the chief points in plain English, hopefully without losing too much of the original content. Because synthesis was his speciality, Empedocles arrived at a new cosmology that unites the conflicting standpoints of Heraclitus and Parmenides and reconciles flux and fire with monism.

Empedocles came to the conclusion that motion and change actually exist and that at the same time reality is fundamentally changeless, allowing the validity of both Heraclitean and Parmenidean doctrines and combining them into a new and surprising concept. As it was said before, Empedocles believed that all matter in the universe is made of the four elements, but he added something unique to the elements: the forces of Love and Strife.

Love and Strife cannot be understood literally; instead Empedocles spoke of them as diametrically opposed cosmic principles, where Love (harmony) is the uniting force that



attracts all things, thereby creating something new, and Strife (discord) is the dividing force that separates and destroys things. This notion bears some similarity to the Yin and Yang principles of ancient China. In the I-Ging, Yin is attributed to the female and Yang is attributed to the male. Together these two principles govern the totality of existence while bringing about cyclical

changes, depending on whether Yin or Yang assumes dominance. This is not unlike Empedocles who contends that the history of the universe is cyclic and eternal and the primary moving factors are Love and Strife.

According to Empedocles, all matter periodically contracts and expands. Under the power of Love everything unites until there is only “The One” - a divine and homogeneous sphere. Then the sphere dissolves under the rising power of Strife and the world is established in a series of stages until it reaches a state of complete dissolution. History then reverses itself, and the universe gradually returns to the state of the irreducible sphere. This cosmic cycle rolls on repeatedly without beginning and without end.

In his own words: “I will tell a two-fold story. At one time they [the elements] grew to be alone from being many, and at another they grew apart again to be many from being one. Double is the generation of mortal things, double their passing away: one is born and destroyed by the congregation of everything, the other is nurtured and flies apart as they grow apart again. And these never cease their continual change, now coming by Love all into one, now again all being carried apart by the hatred of Strife. Thus insofar as they have learned to become one from many and again become many as the one grows apart, to that extent they come into being and have no lasting life; but insofar as they never cease their continual change, to that extent they exist forever, unmoving in a circle. [...]

And in addition to them nothing comes into being or ceases. For if they were continually being destroyed they would no longer exist. And what would increase the size of the universe? And whence might it come? And where indeed might it perish, since nothing is empty of them? But these themselves exist, and passing through one another they become different at different times - and are ever and always the same.” (Simplicius, Commentary on Physics, 31.30)

This can be wrapped up in precise scientific terms. The last passage expresses the idea that the sum of all things in the universe is constant. Since we know that matter can be transformed into energy this is not quite correct, but we may disregard this subtlety because Empedocles made no distinction between matter and energy. The basic idea still holds in view of Einstein's principle of mass-energy conservation. Moreover, Empedocles' cosmology can be thought of as an anticipation of modern cosmology if we identify the state of complete unity with the hypothetical state of all matter being condensed into energy at the moment of the Big Bang. Since our universe is presently expanding, according to Empedocles, we would then live in the age of (rising) Strife.

Empedocles was remarkably ahead of his time. He made several noteworthy statements, such as that the moon would shine by reflected light and that solar eclipses are caused by the interposition of the moon. He held that light takes time to travel, but so little time that we cannot observe it. He also discovered at least one example of the centrifugal force: if a cup of water is whirled round at the end of a string, the water does not flow out. In addition, Empedocles conceived of a fanciful version of the theory of evolution which included the idea of survival of the fittest. He stated that in prehistoric times strange creatures had populated the world of which only certain forms had survived. Though, it must be granted that Empedocles' vision is somewhat crude and bizarre, compared to the painstaking investigation that led Darwin to the same conclusion two thousand three hundred years later.

The following are excerpts from the book *On Nature*, in which Empedocles describes the fantastic creatures that preceded mankind: "Come now, hear how the shoots of men and pitiable women were raised at night by fire, as it separated, thus - for my story does not miss the mark, nor is it ill-informed. First, whole-natured forms sprang up from the earth, having a portion of both water and heat. Fire sent them up, wishing to come to its like, and they showed as yet no desirable form in their limbs, nor any voice, nor member native to man." (Simplicius, Commentary on Physics 381.29)

"Here many neckless heads sprang up. Naked arms strayed about, devoid of shoulders, and eyes wandered alone, begging for foreheads. But when they mingled, these things came together as each happened and many others in addition were continuously born." (Simplicius, Commentary on the Heavens, 586.6)

"Many grew double headed, double-chested - man-faced oxen arose, and again ox-headed men - creatures mixed partly from male partly from female form, fitted with dark limbs." (Aelian, *The Nature of Animals* XVI 29)

# Anaxagoras

[Clazomenae, 500-428 BC]



Anaxagoras was born in Clazomenae at the coast of Asia Minor around 500 BC. He spent much of his life in Athens, where he was associated with Pericles, the leading statesman of the age, and with Euripides, the writer of tragedies. At the time of the two Persian wars (490 BC and 480 BC) the greatness of Athens was at its peak after the city was victorious two times and gained great prestige in Greece.

A golden age started; the city became rich and prospered under the wise leadership of Pericles, who governed, by the free choice of its citizens, for about thirty years until his fall in 430 BC. "Pericles fell in, it seems with Anaxagoras, who was a scientific man; and satiating himself with the theory of things on high, and having attained to a knowledge of the true nature of intellect and folly, which were just what the discourses of Anaxagoras were mainly about, he drew from that source whatever was of a nature to further him in the art of speech." (Plato about Anaxagoras).

With his fall of Pericles' government, Anaxagoras was urged to leave Athens. He fled to Lampsacus in the Troad where he died, an honoured guest, in 428 BC. Anaxagoras is said to have written only one book. As a follower of the old Milesian school he tried to revive the thoughts of Anaximenes in the post-Parmenidean period. Anaxagoras agreed with Empedocles that all coming into and going out of being is merely the composition and decomposition of existing substances, but he rejected Empedocles' Love and Strife theory, probably because there was no scientific reason that spoke for it.

He held that everything is infinitely divisible and that even the smallest portion of matter contains some of each element. This is in some sense the antithesis to the later atomistic theory of Leucippus and Democritus. Anaxagoras held that snow contains the opposites of black and white and is called white only because white predominates in it. In a sense, then, each part contains the whole of reality, each thing containing a specific share of all other things. The differences in form result from different portions of the elements. The variety of substances and forms we perceive is thus explained by the complexity of seemingly endless numbers of possible combinations.

Although these thoughts contradicted the dominant Pythagorean and Eleatic schools, they were not entirely new. Yet, Anaxagoras went a step further. The process by which matter is formed, he argued, is separation. The material world, which springs from the all-containing "One" creates itself through continuous dichotomisation. It produces forms of multiplicity with increasing complexity. According to Anaxagoras, this process is originated and controlled by "mind" (nous).

The idea of mind as the supreme ordering principle is the most captivating aspect of his philosophy. Anaxagoras says that “mind is something infinite and self-controlling, and that is has been mixed with no thing, but is alone itself by itself.” (Simplicius).

Unfortunately this is nearly all he has to say about mind. Neither does he go into detailing the nature of mind, nor does he present a theory that explains the unfolding of reality on basis of mind. Anaxagoras’ concept of mind stands like an overture without a symphony.

“Together were all things, infinite both in quantity and smallness - for the small too was infinite. And when all things were together, none was patent by reason of smallness; for air and ether covered all things, being both infinite - for in all things these are the greatest both in quantity and size. [59 B1] For the small there is no smallest, but there is always a smaller. [B 3] In everything there is a share of everything - except mind - and in some things mind is present, too. [B 11] Other things possess a share of everything, but mind is something infinite and self-controlling, and it has been mixed with no thing. It is the finest of all things and the purest, and it possesses all knowledge about everything, and it has the greatest strength. And mind controls all those things, both great and small, which possess soul. [B 12]” (Simplicius, Commentary on the Physics, 300.27 - 301.10)

Aristotle, who was also a resident of Athens, said a hundred years later about Anaxagoras: “I once heard someone reading from a book of Anaxagoras and saying that it is mind which arranges and is responsible for everything. This explanation delighted me and it seemed to me somehow to be a good thing that mind was responsible for everything - I thought that in this case mind, in arranging things, would arrange them all, and place each, in the best way possible. So if anyone wanted to discover the explanation of anything - why it comes into being or perishes or exists, he would have to discover how it is best for it to be or to be acted upon or to act... Now, my friend, this splendid hope was dashed; for as I continued reading I saw that the man didn’t use his mind at all, he didn’t ascribe to it any explanations for the arranging of things but found explanations in air and ether and water and many other absurdities.”

Aristotle’s judgement may sound overly harsh. At any event we can give Anaxagoras credit for producing an interesting synthesis from the ideas of his influential predecessors Parmenides who said “All is One”, and Empedocles who held that two opposite forces govern the universe. In the cosmology of Anaxagoras, these different forces are distinct manifestations of the same “nous”. Although Anaxagoras did not explain it in detail, this idea provided the seed for later metaphysical speculation.

Anaxagoras was also an astronomer and a man of science. He observed vortexes and spiral phenomena in nature, which fascinated him. He believed the world was created through the rotary motion of a spiral, where initially all mass was united in the centre and then, by centrifugal force driven by “mind”, things came into being through the separation of mass



into an increasing number of bodies and substances. It is unlikely that Anaxagoras derived this idea from the observation of spiral galaxies in space, because their structure cannot be observed by the naked eye and the Greeks did not have telescopes.

However, it is conceivable that he had concluded this from looking at the Milky Way, our own galaxy, which appears to us as a band on the firmament. With some imagination he might have envisioned the band as a disk-shaped spiral of stars with our own planet being located somewhere along its plane (in fact our solar system is located in the outer region of one of its arms). Whether Anaxagoras had a conception of galaxies at all is questionable. There are no records of such observations and it would take considerable visualisation power to deduce the shape of a spiral galaxy. The successors of Anaxagoras did not think very highly of his vortex theory, and so the idea was dropped soon.

Today, we know that if the mass of a galaxy was concentrated at its centre, it would have created a black hole and the gravitation would have been too strong to allow anything to emerge from it, at least not through rotary motion, and most likely not through mind. In spite of this, the concept of mind as the force and the idea that it drives things was highly original and had a significant impact on later philosophers.

## Leucippus and Democritus

[Abdera, 460 - 370 BC]



With the work of Leucippus and Democritus ancient Greek philosophy reaches its zenith when the initial question of Thales after the true nature of matter culminated 180 years later in the subtle concept of atoms, which bears an amazing resemblance to the twentieth century's view of chemistry. For this reason, Leucippus and Democritus have undoubtedly deserved the first prize for the best guess in antiquity, as far as natural science is concerned.

Unfortunately their contemporaries did not share their views with the same enthusiasm.

Leucippus is a very shadowy figure; his exact dates are unknown, some even say he never existed, but it is likely that he was a contemporary of Empedocles (around 440 BC) and that he came either from Miletus or from Elea. Democritus, who was a disciple of Leucippus, is a more certain figure. He was born 460 BC in Abdera in the north of Greece and died at the age of 90 years, after leaving an expansive work elaborating his philosophy including the atomistic theory in great detail. Democritus has written approximately 70 books and hence overshadows his master by far. Unfortunately none of his writings remained intact, but a great deal of what he said has survived in Epicurus.



The atomistic theory began as an endeavour to overcome the odd logical consequences of the Eleatic school. Leucippus and Democritus did not accept the Eleatic hypothesis that “everything is one” and that change and motion is an illusion. Parmenides had said the void is a fiction, because saying the void exists would mean to say there is something that is nothing, which he thought is a contradiction in itself, but he was deceived by thinking of “being” in the sense of “material being”. Thinking of the void as real would have overthrown Parmenides’ theory, because allowing the void to exist as “space bereft of body” (Aristotle) with adjoining plenums implies the opposite of classical monism.

Overthrowing monism was exactly what Leucippus and Democritus intended. They succeeded elegantly by inventing the concept of atoms, for which they are still known. Democritus began with stating a notion of space that served as its premise. Rather than an attribute of matter that describes its extension, Democritus characterises space as a receptacle for stationary and moving objects, which –under certain circumstances– can as well be completely empty.

Twenty centuries later, Sir Isaac Newton had set forth the receptacle standpoint from where he developed his mechanics. He had a bitter controversy with Leibniz who held, on somewhat different grounds than Parmenides, that space is a system of relations. Today, we realise that both views about space were inaccurate because space can be without solid matter, but it always contains some form of radiation. We also know that the geometry of space is defined by mass, hence, the concept of space as a property of “what is” is closer to the understanding of contemporary physics, therefore Newton is likely to lose this argument today.

Leucippus and Democritus did not care to refute the Parmenidean paradox about the void, instead they simply ignored it, which proved to be useful, because it let them constructively explain motion and change. Change, they explained, is an observation that does not deceive the senses; change is real, it happens on account of the recombination of more rudimentary substances.

Previous Greek philosophers had already raised this point, but prior to the atomists none of them was able to provide a satisfactory explanation for what “substance” is. It was Leucippus’ and Democritus’ endeavour to develop a theory that would be consistent with sense perception and -by virtue of logical coherence- not contestable by the Parmenidean arguments.

They held that the nature of things consists of an infinite number of extremely small particles, which they called atoms. Atoms are physically, but not geometrically, indivisible. Democritus described atoms as being indestructible and completely full, i.e. containing no empty space. Because of their indestructibility, atoms are eternal. The notion of the atom itself as an “eternal oneness” may be interpreted as a concession to the Eleatic school.

According to the atomists, nature exists only of two things, namely atoms and the void that surrounds them. Leucippus and Democritus thought that there are many different kinds of atoms, each distinct in shape and size and that all atoms move around in space. Surprisingly they did not deem it necessary to give a reason for the motion of atoms, whereby they avoided the sort of logical mistakes that other philosophers had made. They denied that the motion of atoms is impelled in any way, instead they held that atoms move at random, like in the modern kinetic theory of gases. Democritus illustrated the movement of atoms with an observation he made in nature. He compared it to the movement of motes in a sunbeam when there is no wind.

The moving atoms inevitably collide in space, which in some cases causes them to be deflected like billiard balls, and in other cases, when the shapes of two atoms match in a way that they can interlock, causes them to build clusters upon collision, thereby forming substances which make up the objects of our perception. In this regard, Democritus' idea reveals an interesting parallel to Pythagoras, who said that all things are numbers. Because the characteristics of an atom can be described in numbers, any substance can be expressed as a combination of these numbers.

It is controversial whether the atomists also regarded weight a quality of atoms. It seems they simply neglected weight, although Democritus had mentioned that "the more any indivisible exceeds, the heavier it is". At this point, the atomists entered into what their predecessors had postulated to be the origin of matter, namely water (Thales), air (Anaximenes), fire (Heraclitus) and earth (Empedocles). They said, quite accurately as we know today, that these four elements are not primordial substances, but are composed of atoms like everything else.

Contemporary science has proven the atomists right. The atom concept finally took shape in 20th century's views of physics and chemistry. We know atoms as particles with a small positive nucleus that is surrounded by clouds of electrons and we know that the size of the entire structure is approximately  $1/10,000,000$  mm. Of course, the antique notion of atoms seems crude by comparison. The characteristics of being indivisible, indestructible, and massive, which had originally been ascribed atoms, cannot be upheld any longer. Today, we also have a better understanding of the internal structure of atoms, and we know that weight, or better mass, is a significant property of atoms.

Nonetheless, Leucippus and Democritus came closer to the truth than anyone else in the following millennium. They developed a fully mechanistic view of nature in which every material phenomenon is seen a product of the atom collisions. Democritus' theory had no place for the notion of purpose and the intervention of gods in the workings of the world. He even held that mind and soul is formed by the movement of atoms. In this regard, his attitude was genuinely materialistic.

Unsurprisingly these views earned Democritus harsh criticism. At a time when orphic beliefs and superstitions dominated the spiritual world, Democritus' atom theory seemed odd. People clung to the belief that their fate was steered by the gods of the Olympus. They were highly uncomfortable with the idea that everything, including human existence, is a product of mere atom collisions. Contemporaries and successors objected that the atomistic theory would leave everything to chance. Plato, for example, does not mention Democritus at all in his works. It is said that he disliked his ideas so much that he wished to see all of his books burned, although it is controversial whether these were his own words.

After Leucippus and Democritus, philosophy made a major turn towards ethics and politics. The atomists were the last in the line of true natural philosophers whose primary subject was the composition and order of the physical universe.

The Pre-Socratic period ended with Democritus. Athens had become the political, cultural and spiritual centre of Greece, preparing the ground for the philosophical giants, Socrates, Plato, and Aristotle whose works outshone the atomists for many centuries. Yet, the atom theory remains one of the most amazing intellectual accomplishments of the antiquity.