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The Birth of Physics in Ancient Greece

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NOTE ON THE TITLE

THIS ARTICLE IS ABOUT THE DIFFICULTIES FACED BY ANCIENT GREEK SPECULATIVE PHYSICISTS IN IDENTIFYING THE WORLD'S ULTIMATE MATTER. I CHOSE THE THEME MAINLY FOR THE SAKE OF THE PUN IN THE TITLE,WHICH WAS

'OH DEAR, WHAT CAN THE MATTER BE?'

WHEN I RECIVED MY COPY OF THE MAGAZINE, I FOUND THAT ITS THEN EDITOR(A GREAT OXFORD SCHOLAR, SADLY NO LONGER WITH US) HAD NOT ONLY INTROUDUCED HIS OWN SUB-HEADINGS, BUT ALSO REPLACED MY TITLE WITH ONE OF HIS OWN CHOOSING! I STILL THINK MINE WAS BETTER.

What is the world made of? What is its matter'! This is a key question which exercised Greek thinkers from the time when philosophy first emerged in the sixth century B.C. The series of brilliantly innovative philosophers from the mid sixth to the late fifth century B.C. came to be known collectively as 'the physicists' ('hoi physikoi'). Physics, in its proper sense of speculation about the nature ('physis') of the world, is the oldest branch of philosophy. It was Socrates, in the late fifth century, who first abandoned physics and took philosophy off in a new direction. As a result, the standard modern name for these early physical philosophers has come to be 'the Presocratics'.

Although matter was in this way the very first issue to get onto the philosophical agenda, strangely enough the Presocratics seem to have had no precise word for it. It was Aristotle in the mid fourth century B.C. who first introduced a term actually meaning 'matter'. His name for it was 'hyle'. This literally means 'wood', but Aristotle adopted it to stand for any material that a thing might consist of. After all, even our own word 'stuff' meant 'cloth long before it gained its present-day meaning: the difference between Aristotle's 'hyle' and our 'stuff is simply that his is a term borrowed from carpentry, ours from clothes-making. A thing's 'matter' is whatever stuff it consists of. A cricket bat's matter is wood, and so is a table's. What makes the one a cricket bat and the other a table is that the matter has been organised - cut, sanded, joined etc. - in two different ways, so as to serve two completely different purposes. Likewise the very same metal may become the matter of quite different kinds of thing - bicycles, penknives, paperclips, coins . . .

Of cricket balls and cocoa

What was it like to look for the basic matter, the stuff of the universe itself? Remember that the ancient Greek world is one without microscopes or other instruments for penetrating below the threshold of vision. It all had to be done by looking and thinking. Aristotle, in a famous passage of his treatise the Metaphysics, described a thought-experiment aimed at isolating pure matter. His idea can be understood along the following lines. Take any ordinary object, say a ball. It has a set of properties: it is round, red, leathery-smelling, hard, solid, heavy, three and a half inches in diameter. . . The list is a long one. If these are all'properties', there must be underneath them something whose properties they all are. What if we try, by exercising our imaginations, to work out what that basic thing is? If we succeed, we will have found ultimate matter.

So we try subtracting the properties one by one, to see what's left at the end. It's easy to start by imagining the ball with its smell removed: what is now left, the thing that the smell belonged to, is an odourless red ball. Next (slightly trickier) imagine it with its colour removed too. We're left with an odourless, colourless ball: what else can it have been that both the smell and the colour belonged to? Next strip away its hardness, its solidity, its weight, and its spherical shape. Is anything left? Perhaps something a bit like air. Carry on in this way until every last property has been scrubbed off. Now we can look to see what's left, and that will be the basic 'matter', the primeval stuff which was shaped into the ball by becoming the bearer of all these properties. And what is left? Nothing at all, Aristotle ruefully admits! The matter has performed a vanishing trick.

Perhaps we went about looking for matter in the wrong way, then. Perhaps a thing's basic matter is not this kind of neutral modelling stuff with no properties of its own, but something with real powers which affect the thing's own behaviour. In his own writings on physics, Aristotle allows that there is some truth in this. If a hammer-head is hard, it gets its hardness from the matter it consists of, iron. If the cocoa in your mug is fluid, chocolatey and sweet, he might allow, it no doubt gets these properties from its ingredients

- milk, cocoa, and sugar. In both these examples, the thing's matter is what does most to determine its nature. Now suppose that we could continue the process downwards, by asking what each of these things - iron, milk, etc. - consists of and gets its properties from. Milk, for example, obviously gets its liquidity from the water in it. If we go on in this way, won't we eventually get down to stuffs so basic that anything else you can think of is built up out of them and gets its properties from them?

Elementary, my dear Aristotle

As Aristotle saw it, this was the path by which the Presocratic philosophers had tried to discover the most basic matter of the universe. And their regular answer, he continues, was that at root everything consists of one or more of the following four items: (1) earth, (2) water, (3) air, (4) fire. These are the famous 'four elements', which were first listed jointly as the world's ingredients by the Sicilian poet and philosopher Empedocles in the fifth century B.C., and after him by most thinkers until the seventeenth century. It is quite natural that the Greeks should have hit on these four. When we look at the world's structure it does seem to consist of these four stuffs, organised into layers. (1) First, beneath us, there is the earth. (2) The earth is itself largely covered by water - a fact which could hardly escape the notice of a people who dwelt around the Mediterranean. (3) Above both of these is the air.
(4) Finally the sky (especially the starry night-sky, far more luminous in ancient times, beforethe arrival of electric street-lighting, than most of us have ever seen it), appears to consist principally of fire, and any fire we create down here naturally moves upwards - as if heading off to join it. It was only too easy to believe that all the things we know - animals, plants. stones, clouds - are formed by combining portions from these four huge reservoirs of matter, and get their distinctive properties from them. Human beings, for example, clearly consist of all four: earth gives us solidity and fire our vital warmth, while the fact that we have to drink and breathe to stay alive would be enough in itself to prove that we consist of water and air too.

This four-element theory is one of great elegance and simplicity. It isn't hard to see why it caught on. Yet wasn't it all, with hindsight, a disastrous waste of time? Don't we know that itis completely false, and that the world in fact consists of collections of strange particles whose properties have little if any resemblance to the likes of earth and fire?

This is too hasty a reaction. In the history of human thought the credits are not assigned simply by deciding whose answer was right and whose was wrong. To think they are is to pretend that we are not ourselves as much part of that same history as Empedocles and Aristotle were. Making sense of the world is an uncompletable task which we have inherited from its originators the Greeks and will in our turn pass on to others.

What is more, the Greek philosophers themselves rarely agreed about anything, even about the four-element theory. Despite its widespread appeal, it quickly gained a rival. In the late fifth century B.C., the philosopher Democritus developed the theory that the world in fact consists of. . . yes, collections of strange particles whose properties have little if any resemblance to the likes of earth and fire. These particles had neither colour nor flavour nor anything else in common with familiar objects apart from shape and size. 'Atoms' was his name for them (literally 'uncuttables'). The rest is history.

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