1 Presocratic Natural Philosophy

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Recent studies have revived interest in the early Greek philosophers as both scientists and philosophers. This chapter explores the relation between these kinds of activity, suggesting that early Greek interests in the possibility of human knowledge and in science support each other. The early philosophers' analyses of knowledge included developing new views about the nature of human intellect and of divinity, making room for human knowledge about the world that does not rely on traditional divine inspiration or warrant.

PRESOCRATIC PHILOSOPHY? PRESOCRATIC SCIENCE?

Who are the Presocratics? And does it make sense to speak of either philosophy or science in connection with them?

'Presocratic' is a label used for identifying early Greek philosophical thinkers of the sixth and fifth centuries BCE. It was coined in the late eighteenth century, and originally was meant to contrast these figures with Socrates (d. 399 BCE), who supposedly was the first to consider philosophical problems in ethics. It is an inexact expression, both because it is chronologically inexact – some of the so-called Presocratics were contemporaries of Socrates – and because not a few of these figures had things to say about ethics. Nevertheless, it is a useful historiographic expression for referring to the earliest period of Greek philosophy before the classical philosophers Plato and Aristotle, and it will be used here in that sense.[1] A line from Heraclitus presents us with what may be the earliest reference to philosophers as such: "those men who are lovers of wisdom (*philosophoi*) must be inquirers into very many things" (DK22B35).[2] This use links being a literal lover of wisdom with curiosity and the activity of inquiry. In the *Phaedo* (96a4–5), Plato's Socrates says, 'When I was young I was an enthusiast for that sort of wisdom (*sophia*) that is called inquiry into nature: I thought it was magnificent to know the causes of each thing, why it comes to be, why it perishes, and why it is.' Here is Heraclitus' inquiry into very many things. The Greek words for 'philosopher' and 'philosophy'

begin to characterise distinct kinds of human activity through their use by Plato (who contrasts Socrates with the earlier inquirers into nature and with the Sophists) and Aristotle. That it is appropriate to link philosophy and the Presocratics is indicated by Aristotle's discussions in Book I of the *Metaphysics*. Moreover, in Aristotle's physical treatises (on physics, biology, meteorology, coming-to-be, and passing-away, etc.), he treats his Presocratic predecessors as scientists like himself. They were not (in Aristotle's view) successful; nevertheless, he sees them as engaged in the same activity because they are trying to give an account of nature. Some contemporary historians of science fret about using 'science' to describe this endeavour, given current concerns about demarcating genuine scientific from pseudo-scientific activity, but we shall not worry too much about the terminology.[3] We will consider the natural philosophy of the Presocratics: their inquiry into the world and their views about nature.

'Nature' (*physis*) is another term about which there is scholarly disagreement. It seems to have its roots in the Greek verb *phuō* (to grow), and it occurs just once in Homer, at *Odyssey* 10.302–6. To aid Odysseus' escape from Circe's enchanted island, Hermes gives him a charmed plant, moly, and in explaining how it will work, 'showed [him] its *physis*: it was black at the root with a blossom like milk'. While Homer stresses the outward appearance, in Presocratic philosophy, *physis* comes to include at least some reference to the basic character of a thing, what is responsible for (or is the cause of) its being what it is, with a strong hint of order and regularity. After all, the way a plant or animal grows or develops is primarily determined by the sort of thing it is; different individuals of a species (say, monarch butterflies) will have slightly different characteristics, yet they all will share a certain pattern of growth and change because they are of the same kind.[4] The Presocratics differ in many ways, but they share a commitment to the idea that the world of nature is orderly in fundamental ways (that is, a *kosmos*, an arrangement rather than a random collection of items), and so subject to explanation: an account or *logos* of it can, in principle, be given. Thus, Aristotle is right to call them *physiologoi*, no matter how unlike modern scientific claims their theories may seem to us. The discussion here will concentrate on early Greek theories of cosmology, meteorology, and astronomy, although during this period interest in mathematics and harmonics also developed.[5] Study of the Presocratics is limited by how little material survives. For Thales of Miletus, traditionally listed as the first of the Greek philosopher-scientists, there is

no surviving written material: indeed, Thales may not have written a book at all (Aristotle seems to be relying on reports about Thales rather than any primary written material: at *de An.* 411a7–8 he attributes a view about soul to Thales on the basis of what has been reported about him[6]). Only scraps of sentences, quoted by later ancient scholars, remain from the works of Anaximander and Anaximenes. For the later Presocratics there is more material, but we have no complete work of any Greek philosopher before Plato.[7]

THE MILESIANS AND XENOPHANES: MEASURE, ORDER, AND INQUIRY

In the *Metaphysics*, Aristotle undertakes a study of 'first philosophy', the highest theoretical study of the principles of what there is. As is usual with Aristotle, he begins by looking to the views of his predecessors – 'let us take up those who went before us in the investigation of being and philosophized about the truth; for it is clear that they speak about certain principles and causes' – and he begins with Thales, as 'the founder of this sort of philosophy' (983b1–4, 20–1). He then says that Thales thought that the basic principle of all things is water; he interprets this as a commitment to water as the material cause and fundamental principle of everything that is, and asserts that most of his predecessors discussed only the material causes of things. Aristotle is proud of his distinctions among four types of cause/explanation: the material (the stuff from which something comes or is made), the formal (the shape or form/nature of a thing), the efficient (the moving cause), and the final (the end [*telos*] towards which a thing develops: the full manifestation of a thing[8]); in his view, earlier thinkers failed to offer adequate scientific and metaphysical theories because they overlooked or were ignorant of one or more of these causes.[9]

Aristotle gives his own treatment of the most general fundamental metaphysical questions; in his system, these questions are about the principles necessary for wisdom, the knowledge of *everything*. Aristotle's individual studies of nature are underpinned by these principles, but are not themselves part of metaphysics; in the first book of the *Metaphysics* Aristotle is not interested in his predecessors' scientific views as such. In turn, it seems that the earliest Presocratics were more interested in tracking, registering, and explaining natural phenomena than in doing more abstract

metaphysics, and so one can sense a misfit between the projects described by Aristotle and the details (such as they can be recovered) of these thinkers' views. The accounts of nature that emerge will generate metaphysical and epistemological questions, and the answers that later Presocratics give to these questions will affect the scientific theories that they propose.

The Milesians may be said to have brought into the study of nature three important notions: close attention to and classification of empirical data about change, the idea of nature as an orderly cosmos, and a mechanism to maintain those orderly changes.[10] Although Thales is said to have predicted an eclipse of the sun, this is unlikely; nevertheless, the testimonia show that Thales was a keen observer of the skies. He seems to have measured the length of a solar year, refined measurements of star constellations used to mark weather seasons, and recognised and marked four seasons (rather than the traditional three) on the basis of close study of the stars.[11] What these activities have in common is a recognition of an orderly system of motions that is manifested by the regular movements of the constellations and the less uniform but predictable motion of the planets.[12] Aristotle notes that, according to Thales, the earth rests on water (this is one of Aristotle's reasons for claiming that Thales recognises water as the fundamental principle and cause); nevertheless, many of the ancient testimonia deal with his astronomical observations and measurements rather than with any thoughts about first principles.

Anaximander did leave at least one book (which is no longer extant); he too speculates about the heavens, but he also had views about the development of the cosmos (cosmogony) and its structure (cosmology). The cosmos developed from an indefinitely large mass of undifferentiated stuff: the testimonia refer to it as 'the boundless', the *apeiron*.[13] Simplicius (whose comment about Anaximander's language at the end of the passage indicates that he was familiar with a text) reports:

> Anaximander … says that the *apeiron* is source and element of things that are, being the first to apply this name to the source. He says it is neither water nor any other of the so-called elements, but some other indefinite (*apeiron*) nature (*physis*), from which come to be all the heavens and the world-orders (*kosmoi*) in them. That from which is the coming-to-be of the things that are, into that

> too is their passing-away, according to what must be; for they give justice [payment] and restitution to one another for their injustice, in accordance with the ordering of time, as he says in rather poetic language.
>
> (DK12B1)

Although Anaximander recognises that the cosmos developed from an earlier stage, that development is neither a coming-to-be from nothing nor the result of a creation. In DK12A10, Pseudo-Plutarch reports that Anaximander 'says that something productive of hot and cold' was first separated off; it is from this that our world develops. In B1, Anaximander asserts that this order is maintained by time, and by this he means that the system (including the heavens and the activities of the seasons) is self-regulating, rather than being maintained or governed by anything external to the system itself (indeed, there is only the natural system itself). This notion of order, i.e. that the natural world is an orderly system (*kosmos*), is a crucial idea in the development of Presocratic views of nature. While it is implicit in Thales, it is this passage in Anaximander about justice, recompense, and the ordering through time that is our first written evidence of it. Here is a rejection of the mythical worlds of Homer and Hesiod with immortal gods driven by passions who erupt into and interfere with the natural world of mortal beings.[14]

Anaximander also had views about the details of the natural world. The evidence we have implies that he offered accounts of a wide range of phenomena: the earth stays put at the middle of the cosmos because there is no reason for it to move (one of the first arguments from sufficient reason); the sun, moon, and stars are open vents fixed on hollow rings of fire surrounding the earth. He estimates the sizes of the sun and moon rings in relation to the earth (the sun ring is twenty-seven or twenty-eight times larger than the earth[15]), and he is reported to have addressed meteorological phenomena: thunder, lightning, thunderbolts, firebursts, and hurricanes, according to the report in Aëtius (DK12A23), all result from wind reacting with cloud.[16] Anaximander also speculates about the origin and development of animals: they were 'engendered in the moist, surrounded by a thorny bark (or membrane), as they reached maturity they moved into drier places, and, breaking out of the bark, they lived a different sort of life for a little time' (DK12A30).

Anaximenes, the third of the Milesians, proposed a mechanism for some of the changes that Anaximander had studied. According to Simplicius (DK13A5), Anaximenes posited air as the unlimited (but not indeterminate) underlying nature and principle (in Aristotle's sense), and then suggested that different physical phenomena are produced from it by condensation (cooling) and rarefaction (heating). Testimonia suggest that, in explaining condensation, Anaximenes had in mind the process of producing felt from wool (DK13A7). Thus, when air is heated and so becomes highly rarified, it is fire; through progressive cooling and condensing, wind, cloud, water, earth, and stone are produced. In his view, motion and change are eternal; Anaximenes relies on both motion and the mechanisms of condensation and rarefaction to explain the phenomena of cosmogony, cosmology, and meteorology, covering many of the same subjects as Anaximander. The Milesians seem to have set an explanatory syllabus that the later Presocratics also follow.

While Thales is supposed to have said that 'all things are full of gods' (DK11A22 from Aristotle in *De anima*) and the other Milesians are reported to have asserted that certain of the heavenly bodies were gods, there is no clear active role for gods to play in these accounts of nature. Anaximander's view seems to exclude them from any sort of explanatory role in nature, and Anaximenes' world is equally remote from the worlds of Homer and Hesiod. The rejection of the traditional view of the gods becomes explicit in Xenophanes of Colophon, who proposed his own accounts of nature and natural phenomena, and is the first of the Presocratics to raise questions about the epistemic status of theories of nature.[17] In one fragment (21B18), Xenophanes denies the possibility of divine inspiration (such as Homer and Hesiod rely on in invoking the Muses), endorsing instead the efficacy of human inquiry. Trusting to human understanding and investigation is a far better path to knowledge:

> Indeed not from the beginning did the gods reveal all things to mortals, but, in time, inquiring, they discover better.[18]

In other texts (DK21B11, B12, B14, B15, B16), Xenophanes rejects and ridicules the traditional accounts of the gods.

While jettisoning the traditional views, Xenophanes proposed his own account of the nature of the divine:

DK21B23: One god greatest among gods and men,
not at all like mortals in body or in thought.

B24: whole he sees, whole he thinks, and whole he hears.
B26: always he remains in the same [state], changing not at all, nor is it fitting that he come and go to different places at different times.
B25: But completely without toil he agitates all things by the thought of his mind.

This unchanging and unmoving divinity (line 1 of B26 addresses change in general; line 2 deals specifically with motion), aware of all things at all times, controls the cosmos by thought alone. Xenophanes replaces the traditional divinity-based accounts of meteorological events with his own naturalism:

> She whom they call Iris, this too is by nature cloud purple, and red, and greeny-yellow to behold …
>
> (DK21B32)

> Xenophanes says that the star-like phenomena on ships, which some call the *Dioskouroi*, are cloudlets, glimmering because of their kind of motion.
>
> (DK21A39; also in Aëtius 2.18.1)

These fragments, together with B18, suggest that the cosmos is a rational system that humans can come to understand by using their innate capacities for reasoning based on evidence. As Mourelatos has shown, Xenophanes developed a full 'cloud-astrophysics' to explain a whole range of meteorological phenomena in a systematic way.[19] The only limit to the extent of the earth is its upper boundary 'here at our feet' (B28): the earth extends limitlessly downward and outward (horizontally). Things on the earth are 'of earth and water' (B29, B33), while the water of the great sea generates winds and mists that become the clouds of the heavenly phenomena (B30).

A summary of some of Xenophanes' views about the natural world shows the extent of his own inquiry and interpretation of evidence:

> Xenophanes says that the sun comes into being each day from the gathering together of small fires, and that the earth is unlimited and surrounded neither by the air nor by the heavens. And there are unlimited numbers of suns and moons, but that all things are from the earth. He says that the sea is salty because of the many mixtures flowing along in it … Further, Xenophanes thinks that a mixture of the land with the sea comes about, but that in time

> (the land) becomes freed from the moisture, and he asserts that there are proofs for these ideas: that shells are found inland and in mountains, and he says that in quarries in Syracuse imprints of fish and seals were found; and in Paros, the imprint of coral in the deep of the marble and on Malta slabs of rock containing all sorts of sea creatures. He says that these things came about when long ago everything was covered with mud, and then the imprint dried in the clay. And he says that all men will perish when the land sinks into the sea and becomes mud, and this change comes about in all worlds.
>
> (Hippol. *Haer.* 1.14 = DK21A33; trans. Lesher)

Although Xenophanes exhibits great confidence in his recommendation of inquiry and in his own accounts of the divine and the natural world, B34 (quoted by the sceptic Sextus Empiricus) can seem to cast doubt on the reliability of his own methods:

> and of course, the clear and certain truth [*to saphes*] no man has seen nor will there be anyone (1)
> who knows about the gods and what I say about all things; (2)
> For even if, in the best case, someone happened to speak what has been brought to pass, (3)
> nevertheless, he himself would not know, but opinion is ordained for all. (4)

This fragment has generated much disagreement (about the scope of 'all things' in line 2, and about the status of seeming or opinion [*dokos*] in line 4, among other things).[20] Given his interest in inquiry and his claims about his own knowledge and expertise (B2.10–22), it is unlikely that Xenophanes is embracing universal scepticism. Rather, he notes a requirement to continue investigating and to be ready to revise in light of new evidence. The sort of certainty that was supposed by earlier poets to be guaranteed by divine inspiration through the Muses is not (and indeed never was) available to human beings. Xenophanes' claims raise new problems for those interested in explaining nature: now, in addition to attempting to explain how things are, natural philosophers face the question of whether any explanation can count as genuine knowledge, i.e. as clear and certain truth. This means that any acceptable theory must now also consider its own epistemic status.

HERACLITUS AND PARMENIDES: LOGOS, BEING, AND *DOXA*

Diogenes Laertius, who says that Heraclitus adopted fire as the principle (in the Aristotelian sense), also commented, 'but he sets out nothing clearly' (22A1.8). The fundamental driver of the Heraclitean system is change in accordance with what he calls the *logos* ('account'), which encompasses the principles of order (much like a set of laws of nature[21]). In B1 Heraclitus announces that he will speak of an account 'which holds forever' and which is independent of his utterance of it.[22] 'All things happen in accordance with this *logos*', and in presenting it Heraclitus says that he will be 'distinguishing each thing in accordance with its nature, and declaring how it is'. It is clear that Heraclitus treats fire as a symbol of this *logos* and of the ordered system (B30), but it is less likely that he saw fire as a fundamental element in the way that post-Aristotelian commentators suggest.[23] Instead, there is a systematic process of interchanging stuffs, and it is this interchange that produces the cosmos:

> 'The *kosmos*, the same for all, no one of gods or men made, but was, is, and will be, fire everlasting, kindling in measures (*metra*) and going out in measures (*metra*)' … 'The turnings of fire: first sea, and of sea, half earth and half fiery waterspout.' For [Heraclitus] in effect says that fire, by the *logos*, i.e. god, that manages all things, is turned through air into moisture which, as a seed for the orderly arrangement, is called sea. From this again comes to be earth and the heaven and things surrounded by them.[24]
>
> (Clem. Al. *Strom.*. 5.14.104.2–5 containing B30 and B31a)

Heraclitus' use of measure (*metron*) as well as the range of changes that he discusses signal that the orderly processes governed by *logos* apply at all levels of the cosmos. The changes in living things can be subject to the *logos* insofar as soul, too, turns out to be part of the system, as a particularly hot and dry manifestation of the vaporous exhalations from the sea.[25] Diogenes Laertius says that 'he relates just about everything to vaporous exhalations from the sea', including day and night and meteorological phenomena, and gives some details of Heraclitus' accounts of the heavenly bodies.[26] Although he is unclear about what the surrounding atmosphere is (one assumes that Heraclitus would say that it, too, is constituted by the exhalations), he does say that there are bowls (or bowl-like formations) in those regions around the earth

(with the hollow sides facing the earth). When the bowls fill with bright vapours, these ignite and produce the light of the moon, stars, and sun. The sun appears to be hottest and brightest because it is in a 'translucent and pure' area closer to the earth than the stars; the starts, being further away, are cooler and dimmer. Although the moon is closer to the earth than the sun, because its region of the atmosphere seems less pure, it is not as bright or hot as the sun. Eclipses and the phases of the moon are attributed to variations in the motions of the bowls. Diogenes Laertius concludes his discussion of Heraclitus' views this way (*Lives*, 9.11 = 22A1): 'He accounts for all the other phenomena in accordance with these [principles? the vapours?] but he does not make clear of what sort the earth is, nor anything about the bowls. And these were his opinions.'

The evidence suggests that while Heraclitus had some interest in the details of cosmology, he was most concerned with questions about the status and role of knowledge in human lives. He makes clear that understanding the *logos* is necessary for living well (and that this knowledge includes natural philosophy), but he claims that simply piling up empirical details through inquiry is not sufficient for understanding (he says at B40, 'much learning does not teach understanding', criticising Xenophanes by name, along with Hesiod, Pythagoras, and Hecataeus). Nevertheless, B35 implies that inquiry (in the Xenophanean sense) is necessary for wisdom. For Heraclitus nature is an orderly system, and genuine knowledge and understanding depend on grasping the system as a whole through understanding the *logos*. Unfortunately, although he is convinced that he himself has this understanding, Heraclitus does not explain how one attains it. Perhaps the point of his riddling teaching is to demonstrate the method without elaborating it.[27]

Parmenides presents a different problem. He argues that genuine knowledge is confined to that which neither comes to be nor passes away, is whole, unchanging, and complete. Only an entity that meets these criteria is genuinely real, and thus genuinely knowable. The difficulties in interpretation are compounded by Parmenides' presentation of his views in a poem written in Homeric hexameters. There are conventional names for the parts of Parmenides' poem: the opening fragment (B1) is the Proem, the arguments about the nature of what-is (B2–8.49) are referred to as 'Truth', and the remaining fragments (B8.50–19; using the DK collection) are called *Doxa* (Appearance). What-is-not (anything that is not what-is) is unreal and therefore unknowable.[28] This would seem to entail that nothing that belongs to the world of sense