47 This even holds for Mejer [62] 3593, who accepts the detailed Heraclitean doxography in Diogenes Laertius as Theophrastean.

48 Diels included only Hippolytus I in his *Doxographi Graeci*, though the verbatim fragments cited in the later books found their way into DK. For Hippolytus' text of these, see Osborne [52] (whose work is overpraised by Barnes [72] and criticized by Mueller [53] and Mansfeld (above n. 45)). On Hippolytus in general, see Mueller [54], who, in my opinion, goes too far in believing that some Gnostics used the early Greek philosophers in ways similar to Hippolytus.

49 Sextus' treatment and quotations of Parmenides seem to be dependent on the same intermediate tradition as those of Diognes Laertius; see Rocca-Serra [63].

50 See Gelzer [64] and Mansfeld [51] 300–307.

51 For Clement see Méhat [70] and A. le Boulluec, "Clément d'Alexandrie," in Goulet [151] vol. 2, 426–31; for Philo, D. T. Runia, *Philo in Early Christian Literature. A Survey* (Assen/Minneapolis, 1993) 132–56. Philo himself is of some importance as a source for a number of early Greek philosophers (see n. 38 above), but it is doubtful whether he or Clement ever consulted the originals.

52 For example, Mansfeld [51] 307–12.

53 No Greek text yet supersedes V. Cousin, ed. *Procli philosophi platonici opera inedita* T. III: *Procli commentarium in Platonis Parmenidem* (Paris, 1864; repr. Hildesheim, 1961). A critical edition by C. Steel is in preparation for the Budé series.

54 Edited by H. Diels, *Simplicii in Aristotelis physica commentaria* (Berlin, 1882–95) and J. L. Heiberg, *Simplicii in Aristotelis de caelo commentaria* (Berlin, 1894). Simplicius' commentaries on Aristotle's *Metaphysics* and *Meteorologica* are lost.

55 M. Tardieu, *Routes et haltes syriennes d'Isidore à Simplicius*, Bibliothèque de l'École des Hautes Études, Section des Sciences Religieuses 44 (Louvain/Paris, 1990).

56 As he says about Parmenides, *In phys.* 144.28. He also notes that he possessed only one of the several works he claims were written by Diogenes of Apollonia, ibid. 151.24–29. For Neoplatonist methods of quotation, see Wildberg [81].

57 The passage was printed as a single fragment in early editions of DK. On the transmission of the poem, see O'Brien [76].

KEIMPE ALGRA

3 The beginnings of cosmology

I. INTRODUCTION: MYTH AND COSMOLOGY

Greek philosophical cosmology did not originate completely out of the blue. The first philosophical cosmologists – usually referred to as Ionian or Milesian cosmologists because they worked in Miletus, in Ionia – could react against, or sometimes build upon, popular conceptions that had existed in the Greek world for a long time.[1] Some of these popular conceptions can be gleaned from the poetry of Homer and Hesiod (eighth century B.C.). In Homer the cosmos is conceived as a flat earth, surrounded by the Ocean (Okeanos), and overlooked by a hemispherical sky, with sun, moon, and stars. In the eighth century the annual course of the sun and the rising and setting of some constellations were integrated into a primitive seasonal calendar. Lunations were used for small-scale calendrical purposes ("the twenty-seventh of the month is best for opening a wine-jar," Hesiod *Works and Days* 814) and at some point – although there are no traces of this in Homer of Hesiod – some form of lunisolar calendar was established.[2]

Traditionally such cosmic protagonists as earth, sun, and moon were thought of, and worshipped, as gods, even if their cult in Greece does not appear to have acquired the status of the cult of the Olympians, well-known from myth and poetry.[3] But even in Homer, when Zeus calls a meeting of the gods (*Iliad* XX.1-18), the rivers, except for Okeanos, and the nymphs also come along. Sun, earth, heaven, rivers, and winds could be addressed in prayers and called to witness oaths. Some Olympians too were connected – and in some contexts even identified – with particular cosmic phenomena (Zeus the cloud gatherer as god of the sky, Poseidon as god of the sea, and so on).

In addition, both within the Greek world and in the cultures of their near-Eastern neighbours mythical stories circulated about the *origin* of the world conceived as the successive birth of such cosmic deities.[4] In such a context, speaking about the cosmos meant speaking about the gods, and theories about the origin of the cosmos (cosmogonies) were actually stories relating the genealogy of the gods (theogonies). The classic early Greek example of the latter category is Hesiod's *Theogony* (second half of the eighth century B.C.).[5] In this work the first stages of the history of the cosmos are depicted as follows (*Theog.* 116-33):

> First of all Chaos came into being, and then broad-bosomed Earth (*Gaia*), a firm seat of all things for ever, and misty Tartaros, deep down in broadpathed earth, and Eros, the most beautiful among the immortal gods, he who loosens our limbs, and subdues the mind and thoughtful counsel of all gods and men. From Chaos, Erebos and black Night came into being, and from Night, again, came Aither and Day, whom she conceived and bore after having mingled in love with Erebos. Now Earth first of all brought forth starry Ouranos, equal to herself, so that it would cover her on all sides, to be a firm seat for the blessed gods forever. She also brought forth large mountains, the beautiful abode of the divine Nymphs who dwell in the woody mountains. She also bore the unharvested sea, seething with its swell, Pontos, without an act of delightful love. Then she slept with Ouranos and bore Okeanos with his deep eddies [...].

In the paratactic way characteristic of (Greek) polytheism, this story depicts the cosmos as a plurality of distinct divine entities: each god has his or her own province. The familiar Olympian gods emerge later on in the story and are even more fully anthropomorphic in character. But also the more "abstract" deities of these first stages, such as Night and Earth, who play their roles just shortly after the first beginnings from primeval Chaos, behave in an anthropomorphic fashion: they make love and beget offspring.

As a story (*mythos*) this may be attractive, but it is only an explanation of sorts. Why precisely god A comes to love god B remains as obscure as are the ways of love in the world of mortals. Readers or listeners may accept these elements of the story as true, but in an important sense they do not really *understand* what happens. Moreover, the explanatory mechanism of gods begetting other gods by making love apparently allows exceptions. The sea, for example,

springs forth from Earth without an act of love. Nor is it in all cases clear why god Y is born from god X: the various stages of the story are not linked in a very perspicuous way. True, in many cases some sort of rationale beyond the birth of one god from another may be thought up, but this is always a matter of *interpretation*, and the sort of connections that such an interpretation may bring to light could be rather diverse. Night, for example, is said to have brought forth Day, and we may surmise that this is because Day follows Night. But elsewhere Night is also the mother of Death (212), perhaps because Night and Death share the same negative characteristics. Again, elsewhere (224) Night is also said to be the mother of Deceit, and some interpreters suggest that this may be because deceptions generally occur at night.[6] But such links are at best associative and vague, and they do not add up to a clear and coherent account.

It is illuminating to compare all this to the first philosophical cosmogony of which the outlines are more or less clear. It was devised by Anaximander a good century after Hesiod's poem. Its outlines have to be reconstructed from various pieces of indirect evidence (in particular ps.-Plutarch and Hippolytus, DK 12 A10 and 11) and opinions differ about a number of the details of this reconstruction. However, the main features of the following account should be fairly uncontroversial.

According to Anaximander (DK 12 A10), the cosmos as we know it originated from an eternal, and eternally moving, qualitatively and quantitatively indefinite primary stuff, the "boundless" (*apeiron*), through a process of successive stages. At the first stage a finite germ (*gonimon*),[7] is separated off from the boundless. It is said to "produce hot and cold," presumably because in some sense these opposites are already contained in it. At the second stage, the hot (apparently flame) and the cold (apparently a kind of moisture or mist) are actually separated, and the flame grows as a kind of fiery bark around the moist centre, part of which dries up and becomes earth. At the third stage, the tension between the opposite "elements" becomes so strong that the whole structure explodes. The fiery bark bursts open and its parts are flung outwards to form fiery rings at various distances around the centre, which still consists of earth and mist (from now on we follow DK 12 A11). Some mist is flung along and envelops the fiery heavenly circles, leaving open only some holes through which fire shines out. The result is the basic structure of

the familiar cosmos: earth, water, and air (three manfestations of the "cold") at the centre, and "wheels" (Aetius II.20.1) of fire enveloped in mist around it at various distances. The fire which blazes through the holes are what we perceive as the heavenly bodies. In the rings of the heavenly bodies the battle between fire and mist continues to play its role: at times the holes are partly or fully closed by mist, at other times fire "regains" them, which accounts for various astronomical phenomena, such as the phases of the moon and eclipses of both sun and moon.

In the course of the process of the earth's drying up, living creatures are generated spontaneously from slime or mud. As fish or fishlike creatures, they are born in the wet parts and surrounded by thorny barks. When they reach the dryer parts, the barks break off and the creatures now live on land for a while. Finally, there is a picturesque account of the generation of the first human beings. Human infants could not have sprung forth in the same way as other creatures, for they are notoriously helpless during the first years of their existence. Hence, we are told, they started out as fetuses in large fish, and only emerged from these when they were strong enough to nurture themselves (see the texts printed at DK 12 A30).

In comparison with Hesiod's account much has changed. Instead of Hesiod's whole range of independent cosmic factors, we now find a more *reductive approach*: various stages of the cosmogony, including the account of the generation of living beings (zoögony), as well as some phenomena in the world as it presently is, are explained by reference to the interaction of only two factors (the hot and the cold), which have separated off right at the beginning from the boundless origin of everything. Furthermore, these basic explanatory factors are no longer more or less anthropomorphic gods. Instead, the genesis of the cosmos is explained in terms of recognizable elements of nature – in other words, the approach is *naturalistic*. Moreover, we can now understand the way the various stages of the process are connected. We know how the cold (in the form of the watery) and the hot interact and tend to destroy each other. Also the introduction of *analogy* adds to the intelligibility of the story.[8] The "germ" that the boundless produces at the beginning and from which the cosmos will grow is presented as a spermlike mass, and at the second stage fire is said to surround the wet kernel as a kind of bark. Indeed there

is a striking similarity between the descriptions of the "birth" of the cosmos and those of the generation of living beings (and humans who are at first "enveloped" in fish). It is perhaps not too bold to speak of the application of a rudimentary biological model of generation.

There is a further difference between the mythical cosmogonies and their philosophical counterparts – a difference of context rather than content, which accordingly is often overlooked. Hesiod's *Theogony* presents itself as a *hymn*.[9] The contents of hymns were not usually original. They tended to articulate and embellish what was already given by tradition.[10] Hence they were particularly fit to be recited at important social or ritual events.[11] This also applied to theogonies, whose main function was to connect the existing pantheon to a supposed origin of the cosmos, and so they were often connected with ritual and cult.[12] No such connections to tradition and ritual are attested (nor are they plausible) for the early Ionian cosmologists. They appear to have indulged in theoretical activity for its own sake, they felt free to speculate, and as we shall see, they had no scruples about devising theories that were in crucial respects radically different from those of their predecessors.

2. THALES AND THE BEGINNINGS OF GREEK COSMOLOGY

The first of the three great cosmologists from Miletus was Thales. In antiquity he counted as the archetypical *uomo universale*: well versed in engineering as well as in mathematics and astronomy, and also involved in the politics of his time. For all that, he probably wrote nothing, and he was a shadowy figure already by the time of Plato and Aristotle. His geometrical activities appear to have been largely of a practical nature, and his astronomical work – most famously, his allegedly successful prediction of a solar eclipse[13] – seems to have been primarily a matter of description and measurement, with no clear connection to his more general cosmological views.

The difficulty of determining what these views were becomes apparent when we examine our earliest and most important piece of evidence, a passage in Aristotle's *Metaphysics* (I.3 983b6-984a4; DK 11 A12):

(1) Most of the first philosophers thought that principles in the form of matter (*hylê*) were the only principles of all things. For that from which all things are, and out of which all things come to be in the first place and into which they are destroyed in the end – while the substance persists, but the qualities change – this, they say, is the element and first principle of things. And this is why they say that nothing comes to be and nothing perishes, because such a nature is always preserved. [...] For there has to be some natural substance, either one or more than one, from which the other things come to be, while it is preserved.

(2) However they do not all agree on the number of first principles and on their form, but Thales, the founding father of this kind of philosophy, claims that it is water – that is also why he declared that the earth rests on water – possibly deriving this view from seeing that the nutriment of all things is moist and that even heat comes to be from this and lives by this; and that from which they come to be is the principle of all things. So this is why he developed his view, and also because he saw that the seeds of all things have a moist nature, and that water is the natural principle of moist things.

(3) There are some who think that also the very early writers who, long before our present generation, were the first to write about the gods (*theologêsantes*), had this view of nature. For they made Okeanos and Tethys the parents of generation [cf. Homer, *Iliad* XIV.201, 246], and they claimed that that by which the gods swear is water [cf. *Iliad* II.755, XIV.271], namely what the poets themselves call the river Styx. For what is oldest is the most honourable, and one swears by what is most honourable. But it may be considered uncertain whether this view about nature is old and time-honoured. However, Thales is said to have explicitly stated this opinion on the first cause.

This passage is part of a larger context in which Aristotle investigates whether and to what extent earlier thinkers anticipated his own theory about the factors (or "causes" as he labels them) that determine the nature of physical bodies and the way they change. Here he is dealing with "matter" (*hylê* or *hypokeimenon*), which he claims to be the only explanatory factor adduced by the earliest thinkers. In (1) he ascribes to this category of philosophers the main features of his own conception of matter, according to which the material principle of a thing (x) is not just that "out of which" (x) has come to be, but also that which persists in the process of (x)'s changing and thus constitutes its "basic stuff." In other words, the material principle is both that *from* which and that *of* which a particular thing is made.

If we were to map this general scheme onto the view ascribed to Thales in (2), namely that the material principle of all things is water, we would have to conclude that Thales claimed not only that all things come *from* water, but also that in some sense they really still *are* water. However, if we take a closer look at what exactly Aristotle ascribes to Thales in (2) and (3), that is, in the passages specifically devoted to him, we get a slightly different picture. Here there is no talk of water as a persisting basic stuff (nor, for that matter, of water as that into which all things will finally dissolve). Instead, the focus is on water as the *origin* of things. According to Aristotle, Thales may have drawn on the analogous cases of nutriment and seed, and these are both things from which something may be said to grow. Further, the explicit link between the idea that the earth rests on water and the claim that water is the principle (*archê*) of things makes good sense only when water is thought of as that *out of which* things such as the earth have arisen – the earth, having emerged from the water, is naturally represented as still resting on it. However, it does *not* make good sense if the assumption is that the earth still *is* water. In addition, we know that the comparison (alluded to in (3)) between Thales' tenet and the mythical views to be found in some poets was in fact made by the sophist Hippias. He is probably Aristotle's source here, in a work in which he grouped together opinions of both philosophers and poets on the basis of similarity (DK 86 B6).[14] Now the particular examples from the poets that Aristotle here provides definitely speak of the *origin* of things: Okeanos and Tethys are described as *parents*, and the point of swearing by the Styx was presumably that it was the oldest, that is, the first, of all things.

It is therefore safest to assume that Thales merely claimed that water was the *origin* of all things, not that all things *are* water. That this was sufficient for Aristotle to include him among the class of earlier philosophers who anticipated his own theory of matter is not as odd as it may seem. Elsewhere Aristotle is ready to submit that the earlier thinkers conceived of the Aristotelian causes in a rather vague and unclear way,[15] and after all, Thales is here said only to be the "founding father" of this kind of approach. So he may well have anticipated only one aspect of Aristotle's conception of matter.[16] His thesis about water, in that case, was cosmogonical rather than cosmological.

Two further observations on our text. First, the problem of the stability of the earth, which Thales is said to have solved by supposing

that the earth rests on water, was to be a recurring problem in early Greek cosmology. However inadequate we may judge Thales' solution to be (because it invites the question on what then does water rest), we may charitably claim that it does reveal a rudimentary degree of systematization insofar as it constitutes a link between his cosmology and his cosmogony. The reductive strategy of using one explanatory factor to account for different *explananda* may be regarded as prefiguring what we find in the more elaborate system of Anaximander.

Secondly, part (3) indicates that Aristotle was unwilling to go along with those, like Hippias, who had claimed that Thales and poets like Homer were basically talking about the same thing. He argues that it is unclear whether Thales' view of nature is really as old as Homer and other poets. Whatever they may have *meant*, they did not *say* the same thing as Thales. They were talking about mythological entities (Okeanos, Tethys, and Styx), not about nature. In order to be juxtaposed to Thales, their words have to be *interpreted*. Thales however, is said to have explicitly stated (*apophênasthai*) his view about water as a first cause of nature. A similar view is expressed by Aristotle's pupil Theophrastus (*ap.* Simplicius *In phys.* 23, 29) who claims that Thales was really the first to "reveal the investigation of nature (*physiologia*) to the Greeks and that, though he had many predecessors, he was so much their superior as to outshine them all." Accordingly, Theophrastus' collection of *Physical opinions*, which is at the basis of much of our sources for early Greek thought, did not include the opinions of the poets. Eudemus, another pupil of Aristotle, treated the history of "theological" views of the early poets in a separate treatise, as a subject in its own right, distinct from the history of philosophy proper (Eudemus fr. 150 Wehrli).

So much for Thales' cosmogony. The information preserved about his conception of the world in its present state, that is, his cosmology, is equally scanty, and here again our main evidence is furnished by Aristotle (*De an.* I 411a7; DK 11 A22):

> Some say that it [i.e., soul] is intermingled in the universe. That, perhaps, was why Thales thought that all things are full of gods.

Aristotle's source, probably Hippias again, told him that Thales had said that all things are full of gods, and he conjectures that this

probably meant that everything is somehow ensouled. In another passage, he also conjectures what being ensouled must have meant according to Thales (*De an.* I 405a19; DK 11 A22):

> From what people say about him, it seems that also Thales supposed that soul is some kind of moving principle – if, that is, he said that the [magnetic] stone has a soul because it moves iron.

Aristotle was apparently unsure about what exactly Thales had said or thought; but if the way he reconstructs his views in these two passages, on the basis of what he himself found in his source, is correct we may assume Thales claimed that there is some principle of motion in the whole of the physical world, even in apparently inanimate objects, and that we may call this "soul" and even "god" or "gods." Some notion of the divine, then, was retained in Thales' cosmology. The same holds true of the theory of Anaximander, who is said to have described the "boundless" as immortal and indestructible. These epithets were traditionally associated with the divine (cf. Aristotle *Phys.* III 203b13-15). Also Anaximenes, the third Milesian in line, called *his* basic stuff air, divine (cf. the texts printed as DK 13 A10). Even if this shows that the world picture of the early Milesians was not fully "secularized," it should be stressed that instead of the more or less anthropomorphically conceived cosmic deities of Hesiod we now have a more depersonalized or "physicalized" conception of divinity that does not readily allow for a description in wholly theistic terms.[17]

From the fact that the Milesians considered their first principle – be it water, air, or the boundless – to be divine, we may infer that they thought of it as somehow alive. As we saw, the evidence suggests that they also considered the cosmos, as the offspring of this first principle, to be in some sense alive. Such a view of the cosmos has been labeled "hylozoïsm" (from *hylê* = matter, and *zoê* = life). The term as such is anachronistic: it was first devised by Ralph Cudworth in the seventeenth century,[18] and strictly speaking, the Milesians had no conception of matter as such.[19] Nevertheless, as a descriptive label it usefully captures a feature of Milesian physics that sets it apart from both Aristotelian physics (according to which matter without form was incapable of producing change), and the cosmologies of the post-Parmenidean generation of early Greek philosophers,

that is, the atomists and pluralists. The atomists and pluralists took over the Eleatic thesis that Being (in their case transformed into the atoms of Democritus, the elements of Empedocles, and the seeds of Anaxagoras) is itself immutable, and they accordingly denied that matter contains an internal principle of change. Hence, Anaxagoras and Empedocles introduced what Aristotle called external "moving causes" (Mind, or Love and Strife), whereas Democritus reduced all substantial and qualitative change to the rearrangement of eternally moving (but not living) and intrinsically immutable atoms. Contrary to these later views, the Milesians indeed appear to have assumed that matter had an intrinsic principle of change.

For all that, hylozoïsm was probably a tacit presupposition rather than an explicitly defended thesis, and it may well be for this very reason that it appears in various guises.[20] At any rate, it was not recognized as a position *sui generis* by Aristotle. As we noted, he did claim that Thales and his successors had only accepted material causes, but he was apparently unable to see matter as anything but inert.[21] That is why he objected against the Milesians that "wood does not make a bed, nor bronze a statue, but something else is the cause of the change" (*Metaph.* I 984a23-26). In his view the early materialist theories easily revealed their own shortcomings in this respect, so that "the very circumstances of the case led people on and compelled them to seek further" (984a18-20) and to discover what Aristotle himself would call the moving cause.[22] In other words, Aristotle had no patience with the idea that water, air, or the boundless can of its own accord change into a cosmos. Yet, this appears to have been precisely what the early Ionian philosophers believed. As an unreflective presupposition, this hylozoïsm was probably a remnant of the mythical world view that saw the elements of the cosmos as living and divine entities. After all, such a world picture was unlikely to be replaced overnight by a full-blown mechanistic materialism in which the cosmos was simply made up of blind and dead matter.

3. THE COSMOLOGIES OF ANAXIMANDER, ANAXIMENES, AND XENOPHANES

We shall now examine some further details of the cosmologies of Thales' successors. Like Thales, whose conception of a flat earth

supported by water was probably indebted to earlier mythological world pictures, Anaximander stuck to the concept of a flat earth, which he thought of as drum-shaped, with its diameter three times its height (DK 12 A10). However, his account of the shape and position of the earth was crucially different. First of all, he dropped the entire idea that the earth needs support. This is Aristotle's report (*De caelo* II 295b10-16; DK 12 A26):

> There are some who claim its equilibrium to be the cause of its remaining at rest – among the ancients, for example, Anaximander. They argue that that which is situated at the centre and equally related to the extremes has no impulse to move in one direction – be it upwards, downwards, or sideways – rather than in another; and since it is impossible for it to move in opposite directions at the same time, it must remain at rest.

It has been claimed that even if we knew nothing else about Anaximander, this theory alone should guarantee him a place among the creators of a rational science of the world.[23] After all, he is credited with two important innovations: the (implicit) introduction of the Principle of Sufficient Reason, and the application of mathematical arguments to a cosmological question. The former claim is no doubt correct: the earth remains in position because it does not have a sufficient reason to move one way rather than another. But the second claim appears to be in need of qualification. It is true that our text refers to an argument from "equilibrium," but it is not clear why we should conceive of this equilibrium in purely mathematical terms. Indeed, elsewhere in Anaximander's cosmology, equilibrium appears to be a matter of opposing forces or elements (the hot and the wet), and it is plausible to assume that it is such a physical equilibrium that is at issue here as well. One might think, for example, of the mutual repulsion of warring opposites, which could explain the tendency of the earth to remain as far away from fire as possible, hence at the centre of the fiery rings of the heavenly bodies.

It may be that a similar conception of physical equilibrium was at the basis of Anaximander's puzzling claim that the ring of the sun is furthest from the earth, and that the rings of the stars (which may or may not include the planets) were closest, with the ring of the moon in between (DK 12 A11). After all, the ring of the sun obviously contains the greatest mass of fire, and given the opposition between fire and earth, it is not implausible that in the course of the process

of cosmogony such a mass of fire should have been flung furthest from the centre.[24] It is also possible that this part of Anaximander's story was simply introduced to account for the apparent fact that the lower rings do not obscure the more remote ones. He may, in other words, have argued that the brighter light of the outer rings simply shines through the comparatively modest amount of mist surrounding the lower rings of fire. Whereas the commonly accepted sequence, with the stars at the greatest distance, would have led to the objection that the sun's ring should blot out part of the ring of the stars at those places where they intersect when seen from the earth.[25] On the former interpretation, we shall have to assume that Anaximander was ready to ignore the appearances (according to which the moon is nearer than the stars) for the sake of the overall system of his cosmology; on the latter, he provided an alternative account of these phenomena. On any account, the particular sequence he plumped for appears to have been closely connected with his idiosyncratic conception of the heavenly bodies as concentric rings of fire enveloped in mist. It was not taken over by any other Greek cosmologist.

Anaximander's attempt to specify the relative distances of these cosmic rings (DK 12 A11 and 18) has also been heralded as the first attempt to describe (part of) the orderly structure of the cosmos in mathematical terms. However, the details are very controversial and a modicum of scepticism is appropriate.[26] Most importantly, we do not really know Anaximander's arguments for choosing the numbers he put forward, and there are no indications that empirical measurements played any role.

Whether the orderly structure of Anaximander's cosmology does or does not involve its being inherently *stable*, is a moot point. The context in Simplicius (deriving from Theophrastus) where the only literal fragment has been preserved allows for different interpretations. It says that Anaximander claimed that:

> ... the source of coming-to-be for existing things is that into which destruction too happens "according to necessity; for they pay penalty and retribution to each other for their injustice according to the assessment of time," as he describes it in these rather poetical terms (Simplicius *In phys.* 24, 17; DK 12 A9; B1).

What is probably the verbatim quotation – here placed between inverted commas – decribes what is going on in what indeed are

"poetical" and anthropomorphic terms. Nevertheless, the idea of time presiding like a judge over warring opposites that pay penalty and retribution for their injustice may plausibly be taken to refer to the orderly sequence of what are basically physical processes. We appear then to be told that processes of physical change, such as the gradual destruction (drying out) of moisture by fire, are reversible and will in fact be reversed. In principle this might simply mean that the predominance of one of the elements is followed by the predominance of the other, and that this process goes on *ad infinitum*.

However, Anaximander may also have believed that his cosmos would eventually resolve back into the boundless, and the text just quoted may accordingly be taken to refer to some sort of cosmic cycle: as soon as fire has "won" and dried out the entire cosmos, it is itself extinguished for lack of nourishment.[27] Such a conception would fit in well with his conception of the cosmos as a living and generated being, for such a being would normally be bound to die and disappear again. On the other hand, it remains unclear how we should envisage the details of the process. Thus one wonders how the cosmos in its final state (either as fire or as moisture) was supposed to be taken up by the quality-less *apeiron*.

According to the Greek biographical tradition, Anaximander's fellow Milesian Anaximenes was his pupil. This is how Theophrastus' account, preserved by Simplicius, presents him (Simplicius *In phys.* 24, 26-30; DK 13 A5):

> Anaximenes, son of Eurystratus, of Miletus, a companion of Anaximander, also says like him that the underlying nature is one and infinite, but not undefined as Anaximander said, but definite, for he identifies it as air; and it differs in its substantial nature by rarity and density. Being made finer it becomes fire, being made thicker it becomes wind, then cloud, then (when thickened still more) water, then earth, then stones; and the rest come into being from these. He, too, makes motion eternal, and says that change, also, comes about through it.

In this report, "the underlying nature" is an Aristotelian term, equivalent to "the material cause." Our discussion thus far has enabled us to see that the application of this term, by Aristotle or Theophrastus, to Thales' water or Anaximander's boundless is misleading because these cover only one aspect of the Aristotelian material cause: water and the boundless are that-from-which things are,

not that *of which* they still consist. In the case of Anaximenes, the application is more appropriate, for not only does he have the cosmos originate *from* air (which is testified elsewhere, DK 13 A6), but he also claims that everything in our world still *is* air.

For the rest there are some obvious similarities with Anaximander: the basic stuff is one and infinite (or quantitatively boundless) and also divine (DK 13 A10). Moreover, of all the then known physical "elements," air comes closest to the qualitative indefiniteness of Anaximander's *apeiron*. It is a fair guess that the particular series of rarefied and compressed forms of air of which our text speaks is based on a rough pattern of common experience: we see air turn into fire or into wind, wind into clouds, clouds into water, water into mud (earth), and mud into stone.[28] However, we do not see a stone or even water turn into a plant. In these cases presumably, some kind of mixture (the sources are silent on the details of the mechanism at work) of primary elements (e.g., earth and water) is required. There is no need to assume that Theophrastus is here projecting back the later (Empedoclean or Aristotelian) conception of elements onto Anaximenes' system.[29] On the contrary, we may note that the basic model that is at stake here can be traced back to Anaximander, whose system implies that *nothing* in our cosmos comes *directly* from the originative boundless, but that all cosmic entities are the result of the joint workings of the opposites which have in their turn come from the *apeiron*.

Some further remarks on Anaximenes' application of compression and rarefaction as an explanatory mechanism. Insofar as we are dealing with a basic stuff whose quantitative changes are observed to account for alterations that are (or appear to be) qualitative, we may give Anaximenes the credit for the brilliant intuition that qualitative differences can be reduced to quantitative factors. All the same, we should note that the basic stuff at issue is not itself quality-less (as are, for example, the atoms of Democritus, which differ only in shape, size, and position), but is air. Moreover, what made later quantitative physics so successful was the application of mathematics to specify and explain the quantitative elements of the theory, and there is no trace of this in Anaximenes.

It was noted earlier that Anaximander used an element of common experience – the way water and fire interact – as the basis of his cosmogonical and cosmological explanations. Anaximenes

continued on the same path and supported his claim that qualitative differences can be reduced to the quantitative process of condensation and rarefaction – and hence that air could turn into other elements when compressed or rarefied – by referring to the phenomenon that our breath is chilled when we compress it with our lips, and warm when we loosen our mouth (DK 13 B1). Anaximenes also resembles Anaximander in his use of analogy to shore up the main features of his cosmology. For he appears to have argued that just as air in the form of the breath-soul (*pneuma*) holds us together, so air surrounds and steers (*periechei*) the cosmos (B2; however, the authenticity of this 'fragment' has been doubted by some scholars).

Like Thales and Anaximander, Anaximenes addressed the problem of the earth's stability: it rides on air like a leaf floating in the wind (A20).[30] The same goes for the heavenly bodies, which are fiery but are supported by air (A7). Their turnings are explained by reference to currents of condensed and opposing air (A15). In abandoning Anaximander's conception of the heavenly bodies as rings, Anaximenes returned to the traditional hemispherical conception of the (cosmos and the) sky, which he compared to a felt cap turning around our head. He accordingly rejected the idea that the sun and the other heavenly bodies move under the earth; instead, he claimed that they are carried round the earth, being obscured part of the time by the higher northern parts of the earth (A7).

We cannot here deal at length with the various detailed explanations of meteorological phenomena, or the basis of the mechanisms of evaporation and condensation, which our sources ascribe to both Anaximander and Anaximenes. Suffice it to say that the views at issue found their way into the Greek meteorological tradition: a number of them recur, for example in Epicurus' *Letter to Pythocles*. The more general outlines of early Ionian cosmology did not have such a lasting impact. In the short run, however, they do appear to have influenced Heraclitus of Ephesus, whose views are discussed at length elsewhere in this book, as well as the enigmatic philosopher-poet Xenophanes, who as a young man left his native town Colophon in Ionia in 546 B.C., when it was captured by the Medes, to settle in southern Italy.

It is indeed more than likely that the latter's critique of the traditional Greek anthropomorphic conception of the gods (DK 21 B5, 14, 15, 16) was partly prompted by the demythologizing of the

physical world by the Milesians. In addition, as was pointed out above, the Milesians did not abandon the notion of divinity altogether, but introduced a reformed and "physicalized" conception of it. It is conceivable and even plausible that this helped Xenophanes to conceive of his "one god" in what may be called pantheistic terms, as a cosmic entity (this appears to be suggested by Aristotle *Metaph.* 1986b21-24; DK 21 A30).[31] Finally, and most importantly from the perspective of this chapter, the ancient testimonies on Xenophanes' general cosmology show that he was in many details indebted to the Ionian tradition. Like the Milesians, he defined that from which all things are, and plumped for earth and water (B29 and 33). Rather like Anaximenes he claimed that clouds are exhalations from the sea, and that the heavenly bodies are ignited clouds (B30 and 32; A32 and 40). He conceived of sea and earth as opposites, engaged in a cyclical process between droughts and floods (A33), an idea that reminds one of Anaximander. He supported this claim by pointing to the existence of fossils in stones in Syracuse, Malta, and Paros, a remarkable example of the use of empirical evidence in support of a cosmological claim.

4. MILESIAN COSMOLOGY AND THE HISTORY OF PHILOSOPHY AND SCIENCE

The picture that emerges from the previous sections shows us that despite an undeniable debt to the tradition of mythical cosmology and cosmogony, the Milesians introduced a way of explaining the physical world that was new in a number of significant respects. Nevertheless their contribution has been assessed in fairly different terms. As we noted, Aristotle thought of their materialistic cosmologies and cosmogonies as the beginning of physics, which he regarded as part of philosophy. This view is still endorsed by the majority of modern scholars, but it has had its critics.

Hegel played down the more strictly physical or scientific importance of these early theories, claiming that their main point was of a more general philosophical character.[32] On the other hand, it has been argued more recently that, although we may be dealing with the beginnings of physics of science, we are not allowed to speak of the beginning of *philosophy*, for the simple reason that nowadays cosmology and physics no longer belong to philosophy.[33] However,

one wonders whether this exclusive application of the term "philosophy" in its narrow twentieth-century sense sits comfortably with the very historicity of the concept of philosophy on the one hand and the conception of the history of philosophy as a discipline *sui generis* on the other. Indeed, one may argue that it would amount to a relapse into the basically unhistorical practice – familiar, for example, from Aristotle – of studying the philosophers of the past from the point of view of, and only insofar as they are relevant to, one's own philosophical views (or, more broadly, the views of the tradition or era one belongs to). Historians of philosophy, by contrast, should be able to bracket their own philosophical views where appropriate. In the present case this would amount to using the term "philosophy" not in any specific sense, but in a sense broad enough to cover what in different ages people (Aristotle, for example) were prepared to regard as philosophy.[34]

Also the label "science" has sometimes been denied to these early cosmologies because they were supposedly still too heavily indebted to the mythical tradition,[35] or too weakly supported by observational data. The latter point is an important one that raises the question of the *method* applied by these early thinkers. If we adhere to what is usually called the "Baconian" picture of science – the idea that science should take its starting point through a series of controlled observations – the theories of the Milesians can hardly if at all be called scientific, for they did not practise detailed and systematic observation. At the same time, it should be acknowledged that the questions that they addressed were for the most part very general ones, such as how the cosmos came into existence. It is hard to imagine how they could have coped with such questions along Baconian lines, that is, without resorting to a fair amount of speculation. Moreover, even their more specific theories were mostly concerned with what Epicurus was later to call *adêla* (nonevident things), that is objects that could not be observed clearly and directly, such as (the nature of) the celestial bodies. As a matter of course their theories about such objects were speculative, as indeed were those of later Greek physicists.

In our century the Baconian theory of science has been attacked forcefully by Karl Popper, who claimed that in general science does not proceed by such simple inductive processes, and that moreover the whole question of how scientific theories originate is of no

importance. Science, in his view, is a matter of daring and interesting hypotheses that are to be judged by their explanatory power and, most importantly, by whether they stand up to criticism and to tests. Popper saw the early Greek philosophers, in particular Thales and Anaximander, as the founding fathers of this kind of scientific approach. Accordingly, he presented early Greek cosmology as a critical tradition to which each philosopher made his own contribution by testing the theories of his predecessors and by coming up with alternative hypotheses. Thales, he suggests, "founded the new tradition of freedom [...] the tradition that one ought to tolerate criticism."[36]

But this "Popperian" picture of early Greek cosmology is as hard to defend as its Baconian counterpart. For one thing, we do not know anything about the alleged tolerance of the Milesians, whereas the evidence on their immediate successors (cf. Xenophanes DK 21 B7 on Pythagoras; Heraclitus DK 22 B40 on Pythagoras and Xenophanes) suggests a self-conscious, scornful, and satirizing attitude towards the work of others, a far cry from the gentlemanly and constructive criticism presupposed by Popper. More importantly, precisely because the theories of the Milesian philosophers were mainly concerned with quite general questions and with objects that were not clearly and directly observable, and because such observational data as were available were of a rough and general kind, we can hardly speak of hypotheses that could be *tested* and *falsified* by any kind of observational evidence.[37]

Where, then, does all this leave us with respect to the "method" of the early cosmologists? We may well acknowledge that they made *some* use of observational data to support their theories (e.g., Xenophanes on fossils) and that they often used familiar phenomena or observable processes as an analogy, and thus as an explanatory model. It is true that this does not amount to a systematic and methodical use of observation, and it is also true that the observational data at issue in the analogies are of the same general kind as the theories themselves.[38] But the introduction of observational features as such should not therefore be pooh-poohed or disparaged. It was new, it helped to make the theories more intelligible, and as such it contributed to the development of a more "rational" world view.

Perhaps we may conclude as follows. Just as the activities of the Milesians cannot be labeled "philosophical" in any specifically *modern* sense of the word, so they are not to be called "scientific" in a specifically Baconian or Popperian sense either. Yet, to do justice to what they initiated and to their position in Greek intellectual history, we might regard them at least as protoscientists, standing at the gateway of the history of that part of ancient philosophy that was called physics.

NOTES

1 For a detailed treatment of how Homer and Hesiod shaped the culture inhabited by the earliest Greek philosophers, see Most in this volume, p. 342.
2 On early calendars and chronology, see Bickerman [83] 27–34.
3 See Burkert [85] 174–76.
4 Some of the main texts have been conveniently collected and translated by Pritchard [125].
5 For the remnants of other early cosmogonies ascribed to Orpheus and Musaeus, see DK 1 and 2; a survey in KRS, 21–33.
6 More examples of such interpretations are in West [135] 35–36.
7 The idea is certainly Anaximandrean, although we do not know whether he actually used the term *gonimon*. For the term *apeiron* (boundless) and its range of meanings in early Greek thought, see McKirahan in this volume, p. 139.
8 On the use of analogy, see Lloyd [108].
9 Cf. *Theog.* 11; 33; 37; 51; and *Works and Days* 654–59, which may refer back to the *Theogony*.
10 It is probably against this background that one should interpret Herodotus' claim (II.53) that Homer and Hesiod basically "gave to the gods their titles and clarified their provinces and (τιμάς τε καὶ τέχνας διελόντες), and made clear their various kinds" (εἴδεα αὐτῶν σημήναντες).
11 Hesiod may well have recited his own *Theogony* at the funeral games of Amphidamas in Chalcis. See West [135] 43–46; J. P. Barron and P. E. Easterling "Hesiod," in Easterling and Knox [95] 52–54.
12 For examples, see Pritchard [125] 1 (on an Egyptian creation myth); 60–61 and 332 (on the Babylonian Enuma Elish and its recitation). For a judicious treatment of various views on the connection between myth and ritual, see Kirk [106] 8–31.
13 A controversial issue: Dicks [170] is extremely sceptical on the astronomical achievements of the Milesians; for a clear and balanced review of the evidence on Thales and the eclipse, see Panchenko [180].
14 On Hippias as Aristotle's source, see Snell [183] and Mansfeld [29].
15 Cf. *Metaph.* I. 4 985a11-15 on Anaxagoras and Empedocles.