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Daniel W. Graham: Explaining the Cosmos

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THE IONIAN PROGRAM



This man [Thales] is supposed to be the originator of philosophy, and from him the Ionian school gets its name. It became the longest tradition in philosophy. (Ps.-Plutarch *Placita* 1.3.1)

TODAY MILETUS is a mound rising above a flat plain dotted with olive trees. On the crest of the mound stands a Roman-era theater, and off to the east some stately marble facades line a swampy depression that is the remainder of a once proud seaport on the Aegean, from which little merchant ships sailed to far-off colonies in the Black Sea, the central Mediterranean, and the Nile laden with *amphorai* of olive oil from the ancestors of today's orchards. With her three harbors and a numerous progeny of daughter colonies, Miletus was the "jewel of Ionia,"¹ and she counted among her citizens not only wealthy traders but also wise men whose names have long outlived their native city. For it was here that Western philosophy and science were born, in the first days of the sixth century BC. The little ships carried with their perishable cargoes words that would echo across the Mediterranean Sea and eventually around the world.

Miletus was the most illustrious of a chain of city-states dotting the eastern shore of the Aegean Sea, colonies of Greeks from the Ionian tribe, who gave the name Ionia to their coastline.² The first prose books were written in their alphabet and dialect, and their culture combined the best of a resurgent Greek civilization, recently emerged from a dark age,³ with borrowings from Egypt and the Middle East. Themselves great traders and colonizers, they had daughter cities in the south from the Nile and Libya, west to the coasts of Sicily and southern Italy, France, and Spain, and north to the Black Sea. Thus they were in touch with almost the whole Mediterranean world including three continents. They

¹ Herodotus 5.28, the inspiration for a recent book: Gorman 2001.

² For surveys of Ionian culture, see Huxley 1966; Emlyn-Jones 1980.

³ See Snodgrass 1971, esp. 328.

had trading posts in the Levant and served as mercenary soldiers in Egypt. Like the European voyagers of the Age of Exploration, they looked at lands of less advanced cultures as ripe for their own taking, but they traveled to the more advanced civilizations of Egypt and Mesopotamia to learn their secrets.

These great civilizations had managed to organize kingdoms and empires under the direction of a single autocratic ruler. Vast bureaucracies ran complex operations from fielding armies to taxing produce. In Babylonia temple priests kept detailed observations of the skies in order to report—and, wherever possible, anticipate—ominous phenomena. Handbooks of omens were kept from about 1700 BC and records of eclipses from around 747 BC. The Babylonians developed a powerful if complex system of mathematics based on the number sixty, which they eventually (in Hellenistic times) used to track the motions of the sun and moon. The most important element of their calendar was the lunar month, which being of variable length, caused them to make minute observations. The Egyptians in their bureaucracy used skilled scribes who had a good knowledge of basic arithmetic on which to base practical questions of ordering supplies and the like. They used a simple but highly practical year of 365 days and made simple astronomical observations.

Both of these great civilizations developed some powerful tools for scientific research, but neither had the concept of a scientific research program. For the Babylonians, astronomical observations served astrology, while for the Egyptians they served both to determine religious festivals and to anticipate the Nile floods and the agricultural seasons. Both civilizations furnished textbooks to teach mathematical procedures and the solution of practical problems, but neither had a system of proofs.⁴ The Greeks learned highly developed crafts and skills from their neighbors,⁵ but could have found no real sciences to borrow. Babylonian archives contained vast stores of mathematical and astronomical data on cuneiform tablets, and Egyptian archives contained vast collections of practical documents on papyrus rolls, which could be used in the service of science. But there was nothing recognizable as an institute or association or organized practice of scientific research.

What the Ionians themselves accomplished, and what their contribution to Western knowledge was, have been the subject of ongoing scholarly debate. Some partisans argue that they fairly invented science, others that they merely speculated about the world in a manner incapable of

⁴ See Neugebauer 1957.

⁵ See Burkert 1992.

producing scientific knowledge.⁶ Recently most commentators have been willing to grant to them a modest status as forerunners of scientific thought, part of a complex combination of activities that were destined to contribute to scientific thought and method, including mathematics, medicine, technology, and public speaking.⁷ While it is surely true that the Ionians provided only one of several ingredients necessary for the creation of natural science, there remains a sense in which they deserve a special place in the history of Western thought.⁸ For a good deal remains to be said about what they accomplished, and how, that will show their contribution as definitive of a new approach, both theoretical and practical, to the world, and in that sense genuinely revolutionary.

In this work I propose to address the Ionians' contribution in a fairly straightforward manner: to retell the story of their intellectual development in a roughly chronological order. But this story will not be just like

⁶ A classic statement of the scientific character of Presocratic philosophy is found in Burnet 1930, 24–30. F. M. Cornford changed from seeing Ionian philosophy as scientific (Cornford 1912) to seeing it as non- or even antiscientific (Cornford 1942, 1952). See the famous reply to him in Vlastos 1955b and later in Vlastos 1975, 86–97. Also for the scientific value of the Presocratics is Popper 1958, disputed by Kirk 1960, with a rejoinder in Popper 1963, reviewed in Lloyd 1967. For a recent assessment of scientific claims, see Barnes 1982, 47–56. For a recent reaffirmation of the scientific character of Ionian philosophy, see Longrigg 1993, ch. 2. For analyses of Presocratic methods, see Stannard 1965; Hussey 1995. An early modern criticism of Greek science is found in Francis Bacon's *The Great Instauration*, preface: “[T]hat wisdom which we have derived principally from the Greeks is but like the boyhood of knowledge, and has the characteristic property of boys: it can talk, but it cannot generate; for it is fruitful of controversies but barren of works.”

⁷ E.g., Lloyd 1979. These activities are not sharply distinguished, nor do they coincide with modern categories: Lloyd 2002.

⁸ For instance, though there were mathematicians who were not philosophers, there were also philosophers who were leading mathematicians; Thales in particular is credited with being the first Greek mathematician on the authority of Eudemus (Proclus *Commentary on Euclid* 157.10–11, 250.20–251.2, 299.1–4, 352.14–18 = A20). Philosophers deeply influenced the medical writers, even when the latter criticized them, e.g., “Hippocrates” *Ancient Medicine* 1, 2, 13, 15, 20; *The Nature of Man* 1, 2; Longrigg 1993, 26 et passim; Heidel 1941, 17–19; Jones 1979, 3–6, stressing the influence of Alcmaeon. Although technology no doubt had a life of its own, Thales is famous for combining science and technology, e.g., Herodotus 1.75.3–5 = A6; recently it has been stressed that Anaximander was in touch with the latest architectural technology of his time: Hahn 2001; Couprie, Hahn, and Naddaf 2003. Likewise, public speaking had a life of its own, often taught in the fifth century BC by sophists. Yet the sophist Hippias wrote a history of philosophy: Diogenes Laertius 1.24, cf. authorities in n. 50 below; and Gorgias took up basic ontology in his treatise *On What Is Not* (B3, Pseudo-Aristotle *On Melissus, Xenophanes, Gorgias* 979a12–33, b20–980b21). In general, Ionian philosophy seems to have helped shape all the intellectual currents of Greece (see ch. 11). The thesis I shall defend here is similar to that of Burnet 1930, introduction; however, his historical account is now obsolete. For a brief but powerful recent statement of the originality and independence of Greek science, see Kahn 1991.

other histories of the Presocratics. In the first place, I will tell the story exclusively from the point of view of the scientific or proto-scientific researchers, those who participated in what I shall call the Ionian tradition, as is rarely if ever done. In the second place, I shall maintain, contrary to assumptions common since ancient times, that Presocratic philosophy is not a mere patchwork of different schools or styles of thought; that the Ionian tradition is the dominant current in Presocratic history; and that even those schools of thought that seem most tangential or most opposed to Ionian philosophy—the Pythagoreans and the Eleatics—are deeply indebted to and even parasitic on the Ionian tradition.⁹ In the third place, I shall argue that several of the key doctrines and positions commonly attributed to the Presocratics—continuously since the time of Aristotle—result from fundamental misunderstandings of the Ionians and their principles. When we get the doctrines of the Ionians right, we may be in a position to see relationships that were not evident before. The result will, I hope, be a more coherent picture of Presocratic development than is usually attained. It will, in any case, be different in important respects from standard accounts which have prevailed for most of the twentieth century.

1.1 Anaximander's Project

The story properly begins, as has been recognized for the last forty years, with Anaximander.¹⁰ Although the first of the Milesians was Anaximander's mentor, Thales, we do not have enough reliable information about Thales to know how the various elements of this thought and practice fit together.¹¹ He viewed water as the source of all things, saw the magnet as somehow animated, studied the stars and allegedly founded geometry; he provided political advice to the Ionians and was famed for engineering feats; he seems either to have traveled widely or to have learned from those who did—or both; he may have brought to his countrymen Egyptian surveying techniques and a curiosity about why the Nile floods; he may have been inspired in his choice of a source by Near Eastern myths;

⁹ I shall not, however, argue the primacy of the Ionian tradition in detail, but rather illustrate it by showing how the tradition developed.

¹⁰ As demonstrated by Kahn 1960, still the standard work on Anaximander.

¹¹ See now O'Grady 2002, the first book-length study of Thales, and Marcacci 2000. Yet I tend to think that these studies are too optimistic in a number of ways. For criticisms of alleged accomplishments of Thales in astronomy and engineering, respectively, see Graham 2002b, 2004b; for one area in which Thales seems to have made an important contribution, see Graham 2003c. For a reasonable view of what he accomplished in astronomy, see White 2002.

he seems to have borrowed from Phoenician sailors a knowledge of the Little Dipper, which, by its proximity to the pole star, provided a point of reference for navigation and orientation. But apparently he left no writings, and consequently he became an enigma even to Aristotle and the researchers of the fourth century BC. Today we are forced to project back interpretations derived from what we can learn from the later tradition. The first Ionian to leave a written record from which his theory could be reconstructed with some confidence is Anaximander. It is indeed likely that Anaximander inherited both his general assumptions about the world and his approach to it from Thales. But we can get a foothold in the Ionian intellectual world only with Anaximander.

1.1.1 *The Pre-philosophical Background*

The idea of explaining the world in a scientific way is so common to us now that we should pause to consider its novelty in an earlier time. Many cultures have creation myths which in some way tell the community that shares the myth how it came about that there is a world, and that explain the present order of things, often including the present religious and political arrangements. The Greeks seem to have had creation myths which shared features with other cultures of the Near East and Middle East.¹² At the very beginning of the historical period, when alphabetic writing was new, these stories were organized and unified by Hesiod, around 700 BC, in his *Theogony*.¹³

In this epic poem, Hesiod tells the story of the origin of the world:

Hail, children of Zeus! Give to me desirable song,
and proclaim the holy race of immortals who ever are,
who were born from Earth and starry Heaven
and Dark night, and whom salty Sea nourished.
Tell how first the gods and Earth came to be,
and rivers and boundless sea, with raging swell,
shining stars and wide heaven above
[and the gods that came from them, givers of good things];
and how they distributed their wealth and divided their honors,
and how first they laid hold of many-folded Olympus.
Tell me these things, Muses, who dwell on Olympus,
from the beginning; and say who was first born of them.
Indeed, first was Chaos born, but then
broad-bosomed Earth, a steadfast seat always of all

¹² Most notably the Hittites' Kumarbi Epic, the Babylonian *Epic of Gilgamesh*, and others; see West 1966, 20–31, KRS 45–6.

¹³ West 1966, 40–48.

[the immortals, who hold the peaks of snowy Olympus],
 and misty Tartarus in a recess of the wide-wayed earth,
 and Eros, who fairest among the immortal gods,
 looser of limbs, of all gods and all men
 overcomes the thought in their breast and their wise counsel.
 From Chaos Erebus and black Night were born,
 And from Night Aether and Day were born,
 whom she bore being with child after mingling in love with Erebus.
 And Earth first bore equal to herself
 starry Heaven, that he might cover her all around,
 that he might be a steadfast seat always for the blessed gods.
 And she bore long Hills, lovely haunts of the divine
 Nymphs, who dwell on the woody hills.
 And she bore the fruitless deep, with raging swell,
 Sea, without desirable love. But then
 lying with Heaven she bore deep-swirling Ocean,
 Coeus, Crius, Hyperion, Iapetus,
 Theia, Rhea, Themis, Mnemosyne,
 golden-crowned Phoebe and lovely Tethys.
 After them was born the youngest, wily Cronus,
 most terrible of her children. And he hated his flourishing sire. (104–38)

Beginning with an invocation to the Muses, the daughters of Zeus who inspire the poet with truths he cannot know for himself, Hesiod recites the beginnings of the world. In an account that has the form of a genealogy, he names the first beings as Chaos, signifying a gap or open space, Gaia or Earth, and Tartarus, or the Underworld. Then dark and light conditions are born from Chaos, while Earth bears Heaven and hills, and in a sexual union with Heaven, Ocean, the body of water that occupies the edge of the earth disk where earth meets heaven. Further, Heaven and Earth beget the race of Titans, who beget the Olympian gods.

Hesiod's story is not a scientific account. In it cosmic beings beget other cosmic and divine beings, who eventually produce human beings. Yet there is an order to the events he describes which provides a kind of systematic explanation for the world, its structures, its inhabitants, and its processes. A begets B, who begets C. Each divine being has its powers and dominion. Earth provides a place for humans to live, Heaven a place for (most of) the gods. Night and Day take turns traveling abroad on earth; Zeus hurls thunderbolts, Poseidon shakes the earth from below the sea. The divinities form alliances, foment plots, and go to war with one another. A succession of divine potentates leads up to the present state of affairs in which the Olympian gods, led by Zeus, control the world. In short, the world has a history which accounts for the way things are now.

How does Hesiod know the history of the world? He calls on the Muses, daughters of Zeus, to inform him of things he does not know. No doubt he has heard similar stories many times told by other bards, who in turn invoked the Muses. Hesiod's stories are not mere inventions of his own: they agree with stories told by Homer and are similar to stories of the Hittite Kumarbi Epic.¹⁴ Yet Hesiod's authority for his story—his version of the truth—is the inspiration he receives from the goddesses of poetry. He tells a story of divine things inspired by divine beings.

1.1.2 Anaximander's Account

Writing in the sixth century BC, Anaximander seems to have also told a story about how the world came to be. But he did not recount it as a tale of divine beings interacting. Rather, he talked about things coming to pass in a natural way, starting with an initial undifferentiated state:

[Anaximander] says that that part¹⁵ of the everlasting which is generative of hot and cold separated off at the coming to be of the world-order and from this a sort of sphere of flame grew around the air about the earth like bark around a tree. This subsequently broke off and was closed into individual circles to form the sun, the moon, and the stars. He also says that in the beginning man was generated from animals of a different species, inferring this from the fact that other animals quickly come to eat on their own, while man alone needs to be nursed for a long time. For this reason man would never have survived if he had originally had his present form. (Pseudo-Plutarch *Miscellanies* 2 = A10)

According to Anaximander, the original state of affairs consisted of some everlasting stuff, which he elsewhere calls “the boundless.” From this primordial stuff some seedlike substance was, as it were, secreted, which gave rise to differentiated things such as hot and cold. From this arose a mass having an earthy nucleus surrounded by a layer of air, surrounded by a shell of fire. The mass burst, producing concentric rings of fire enclosed in air, surrounding a cylindrical earth. The rings are invisible because of the air surrounding them, but a hole allows the fire inside to be seen.¹⁶ The outer ring is that of the sun, the middle that of the moon, and the inner ring, or, presumably, set of rings¹⁷ are those of the stars. We

¹⁴ See n. 12 above.

¹⁵ Reading τ with Kahn.

¹⁶ Hippolytus *Refutation* 1.6.3–5 = A11, Aëtius 2.20.1, 2.21.1 = A21, and *ibid.* 2.25.1 = A22.

¹⁷ Hippolytus, *ibid.* (see previous note), 5, describes plural rings for the stars. In a recent reconstruction, Couprie 1995; Couprie, et al. 2003, 224–26, hypothesizes a “virtual cylinder.” (However, he seems to withdraw or qualify the notion at 227–228.)

see also that he pursues his account all the way to the formation of human beings out of other creatures.

The earth gradually dried out:

Some say the sea is what is left of the original moisture. For the region about the earth was first moist, and then part of the moisture was evaporated by the sun, and winds arose from it and the turnings of the sun and moon, because their turnings are produced as a result of these vapors and exhalations; and where there is an abundance of moisture for the winds, the turnings take place. And what is left of the original moisture in the hollow places of the earth is sea. Accordingly it continually diminishes as it is dried out by the sun and finally some day it will be dry. Anaximander and Diogenes held this view, as Theophrastus reports. (Alexander of Aphrodisias *On the Meteorology* 67.3–12 = A27)

The muddy earth gradually became drier and perhaps eventually will be completely dry. Life arose in the primeval seas and moved to land:

Anaximander said the first animals were generated in moisture surrounded by a prickly bark or shell, and as they matured they moved onto land and breaking out of their shell they survived in a different form a short while. (Aëtius 5.19.4 = A30)

Because human offspring must be nourished for a long time before they are self-sustaining, they must have been born as adults.¹⁸ Anaximander explains that they were nourished inside fish until they reached maturity. When the fish burst open, adult humans emerged to populate the land.¹⁹

The fiery bodies of heaven are, as we have said, holes in the heavenly rings through which the inner fire shines out. The phases of the moon result from the periodic opening and closing of the aperture on the middle ring. Moreover, eclipses result from a sudden blocking of the apertures of the sun and the moon. Winds bursting out of clouds cause lightning and thunder, and other winds cause the “turnings” of the sun, or solstices, which govern the seasons.²⁰

1.1.3 *The Structure of the Account*

We find in this account a kind of pattern which will be important for later accounts.

(1) There is a source from which everything arises:

¹⁸ As Ps.-Plutarch explains in the passage quoted above.

¹⁹ Censorinus 4.7, cf. Plutarch *Symposium* 730e = A30; Hippolytus *Refutation* 1.6.6 = A11.

²⁰ A23, A24, A27.

Anaximander was the son of Praxiades, of Miletus. He said the source and element was the boundless [*to apeiron*], not defining it as air or water or anything else. And the parts change, but the totality is changeless. (Diogenes Laertius 2.1)

In Anaximander the source is incurably vague: the boundless or the everlasting. Obviously there is something there which seems always to have been there, and to be everywhere. But what kind of thing it is and what kind of qualities it exhibits are not expressed. Presumably it is some indeterminate stuff that cannot by itself be described or identified. But there is certainly no thought of *ex nihilo* creation.

(2) There is a process by which the constituents of the world arise out of the originative stuff. First a seedlike stuff appears, then contraries. We next meet with earth, air, and fire. Their precise relation to the emergent contraries is not made clear. It is possible that some further stage of organization takes place by which the contraries give rise to the stuffs. But it is also possible that the contraries are just an abstract way of referring to the stuffs needed to make the world.

(3) The constituent stuffs of the world are organized into the material layers of the world, the *maxima membra mundi*, as Lucretius will call them. Thus the fire, air, and earth form the cylindrical earth surrounded by the rings of heaven.

(4) The structures and materials of the world are stabilized into the state of affairs we are familiar with in the world. The earth dries out so that it consists mostly of dry land in the hollows of which seas, the residue of primeval moisture, are found. Water is evidently one of the cosmic materials, even though it is not mentioned explicitly in reports of Anaximander's cosmogony. The present world is stable, though over a long period of time it may yield to a sort of greenhouse effect and dry up completely.

(5) Living things emerge. They are formed in the seas when moisture prevails, and some things migrate to land by emerging from shells or from aquatic life-forms that produce them.

(6) A wide variety of phenomena are explained by the model. The phases of the moon, lunar and solar eclipses, thunder, lightning, seasonal variations are all accounted for.

This list identifies the content of Anaximander's account. At first sight his account appears impressive in its breadth of conception and the extent of its application. But content alone is not sufficient to establish the scientific character. We may see this by comparing Hesiod's mythological account in the *Theogony* (supplemented by a few points from his *Works and Days*).

In Hesiod we find (1) a source of all things, Chaos, the great yawning gap, the womb in which the world takes shape. (2) There is a process by which the parts of the world appear, namely birth. Indeed, we may distinguish asexual reproduction, which takes place a number of times in the early stages of the cosmogony, and sexual reproduction, which takes place under the influence of Eros, one of the first figures to be born. (3) The structures of the world are born so as to constitute the existing world, as Hesiod's generation understood it, consisting of a flat, circular earth topped by a vaulted heaven and supported by a vaulted underworld, Tartarus.²¹ (4) Through dynastic struggles among the leading deities a political/religious order emerges with Zeus as the ruling figure.²² (5) The human race is created in several successive generations, leading up to the ill-starred present generation.²³ (6) Many phenomena of the world are accounted for by the presence of titular deities who govern them. Zeus throws thunderbolts, Poseidon shakes the earth, Iris produces the rainbow, and so on.²⁴ A mythological account can, then, cover the same territory as the proto-scientific account of Anaximander. Indeed, Anaximander and his followers do in a sense continue the tradition of Hesiod in important ways.²⁵ But there are important differences in the two kinds of narrative.

1.1.4 Scientific Features of Anaximander's Account

What makes Anaximander's account fundamentally different from mythological accounts is not the content and scope of the explanation, but the method. In Hesiod the items that do the explaining, the *explanantia* (singular: *explanans*), are divine persons; explanation consists of showing how a divine person or pair of divine persons begot another divine person. Or, in later stages of the story, it consists of showing how these persons interacted with each other in quasi-human interactions—for instance alliances, ambushes, and battles—to bring about the present state of the world. In Hesiod, to explain the world is to show how it arose from the interactions of supernatural persons.

By contrast, (A) in Anaximander the explanantia are natural events or things: fire, air, earth, wind in clouds, hot and cold. Even the more inscrutable items in the narrative—the boundless, and what is productive of hot and cold—are portrayed as natural entities.

²¹ The symmetry of Heaven and Tartarus is seen at *Theogony* 721–6.

²² *Theogony* 666–720.

²³ *Works and Days* 174–201.

²⁴ E.g., *Theogony* 501–6 tells how Zeus was given thunderbolts as a reward for services rendered.

²⁵ See Stokes 1962–1963; Diller 1946.

(B) Similarly, the things to be explained, the *explananda* (singular: *explanandum*), are all natural events or things. In Hesiod, on the contrary, it appears that the poet is out to explain not only natural events but also mythological events such as the consignment of the Titans to the underworld, and religious practices and beliefs such as the worship of the Olympian gods. In Anaximander there are no corresponding mythological *explananda*. Only observable events seem to come in for consideration.

(C) In consequence of (A) and (B), we may ascribe to Anaximander a *closed system of natural explanation*, in which one privileged set of natural phenomena explains other natural phenomena. There is no room for a second set of items apart from those found in nature. There is no “Two-World” theory as in Plato, for whom sensible things are to be explained in terms of nonsensible Forms which exist outside of the natural world. Much less does Anaximander appeal to supernatural beings or their actions to account for phenomena. The world of nature is autonomous and, in a certain sense, self-sufficient for explanation. Consequently, the system leaves no room—or rather, only a limited role—for the supernatural.

(D) In Anaximander’s system of explanation, *explananda* are accounted for by showing how they arose out of or are constructed out of simple materials. Roughly, the kind of explanation Anaximander uses is material cause explanation. The concept of material cause comes from Aristotle; I shall have occasion to modify his particular account of it as it applies to the Ionians. But it will serve as an initial approximation: Anaximander explains the world by deriving it from a certain kind of matter or stuff. In Anaximander there is also a strong component of genetic explanation: showing how the world and its contents arose in a kind of unique historical development.

(E) Anaximander develops his account in prose (even if the prose is enriched with poetic terms).²⁶ His work is, in fact, a pioneering work in prose.²⁷ The medium invites an everyday understanding of events as it avoids the magical and marvelous dimension of poetry. The author’s use of prose seems to underline the natural, commonplace character of the account, avoiding appeals to the supernatural. And it seems to allow for evidence and argument to support the claims made. Today, we take for granted the value of prose expression for communicating scientific information, but in a time when the alphabet itself was new and literacy limited, when written communications were few, and when the prestige of verse was unchallenged, the choice of prose marked an important departure from previous norms of communication.²⁸

²⁶ Simplicius comments on the poetic diction of B1, to be discussed in the next chapter.

²⁷ Perhaps the very first prose treatise: Kahn 1960, 240.

²⁸ Greek epic poetry seems to have been composed orally and is adapted to memorization: Parry 1971; Lord 1960. There has been much work on the role of literacy in early thought;

(F) Anaximander appeals to the evidence of experience. If Hesiod's authority comes from the Muses,²⁹ or more generally traditional lore, Anaximander can claim only that he makes reasonable connections among phenomena. For instance, in his account of the human race (as seen in Aëtius and Pseudo-Plutarch above, A10 and A30), he *infers* that humans were born out of sea creatures because they cannot nourish themselves when they are young. He uses information about the nature and behavior of things (including human beings) to construct a rational account of how they must have arisen or how phenomena such as meteorological events take place. The sole grounds for his account are reason and experience (both taken in a fairly ordinary sense), not inspiration or tradition.

Roughly, characteristics (A)—(F) can be said to be shared by modern science.³⁰ There are, no doubt, significant differences in the standards of rigor between the Ionian conception and the modern practice of science—none so great as the notion of what constitutes experience in (F). I shall maintain that what the early Ionians have in mind is plain, everyday encounters with the world in which the objects around us are taken more or less at face value. By the end of the Presocratic period, under the pressure of philosophical criticisms, ordinary experience will become problematic.³¹ Nevertheless, the first historical step in quasi-scientific explanation seems to arise from showing how remote and apparently portentous phenomena can be understood in terms of everyday events. Of course, modern science has taken the notion of experience to ever greater levels of precision as it tracks nanoseconds and nanometers and collects photons from rare collisions with neutrinos. What seems to be missing from Ionian scientific inquiries, from a modern point of view, is an effective way to test theories and adjudicate between rival hypotheses. The modern scientific community spends vast sums of money constructing particle accelerators, telescopes, satellites, and other powerful instruments designed to collect data that can determine the validity of theories. By contrast, the Ionians seem rich in hypotheses but poor in efforts to test or evaluate them. As an initial approximation, we may conjecture that the program of the Ionians embodies a necessary condition for science as we know it: naturalistic

see Robb 1983a; on preliteracy and the Presocratics, see Havelock 1966; on the general question of Greek literacy, see Harris 1989. An even more basic question than in what form to publish one's ideas is the question whether one should publish them at all. The early Pythagoreans may have forbidden publication of their ideas, and hence did not enter the intellectual mainstream until some of their members ignored the ban; see Burkert 1972, 218–38. On the titles and transmission of early cosmological works, see Schmalzriedt 1970.

²⁹ *Theogony* 104–15, quoted above; cf. Homer *Iliad* 2.484–93, where the Muses are Homer's informants for the catalog of ships because they were eyewitnesses.

³⁰ Cf. a list of characteristics in Long 1999, 13 (which is more general).

³¹ Cf. Democritus B6–8, B9, B10, B11.

explanation of phenomena, but that it falls short of providing sufficient conditions for science insofar as it lacks a plan for testing hypotheses in relation to the world.

At this point we seem to see a strong contrast between a religious-mythological approach in Hesiod and a secular-rational approach in Anaximander. But is this too hasty?³² Certainly Anaximander did not shun the religious dimension cosmology:

For that reason, as we say, there is no source of the infinite, but this seems to be a source of everything else and to contain all things and to steer all things, as everyone claims who does not posit some cause beyond the infinite, as for instance mind or love. [B3] And this is the divine, for it is deathless and imperishable, as Anaximander says, and most of the natural philosophers. (Aristotle *Physics* 203b10–15 = A15)³³

Anaximander declared the countless heavens to be gods. (Aëtius 1.7.12 = A17)³⁴

Aristotle rightly notes that Anaximander assigns divine attributes to his boundless, and he treats it as somehow having the ability to control the world; the world itself, or the several successive worlds, if there are such, seem also to have divine attributes.³⁵ Yet we must not overlook the vast difference between Homeric or Hesiodic divinities and Anaximander's divine beings. Homer's Zeus asserts his ascendancy over his fellows on the basis of his ability to win a cosmic tug-of-war—though he can be waylaid if he is not careful.³⁶ Hesiod's Zeus rules in part by wisdom, but he too must be on the lookout against palace coups.³⁷ Zeus's rule is a very personal one in which he punishes wicked deeds with penalties which he metes out on the basis of the particular crime, as in the case of Prometheus: because Prometheus steals fire for man, Zeus chains him to a rock to have his liver eaten by a bird, while he sends Pandora with a box of evils for men (not least of which is the female sex embodied in Pandora herself).³⁸

³² For a discussion of the question of myth and rational discourse, see Lloyd 1987, ch. 1.

³³ Cf. Kahn 1960, 43–44.

³⁴ See other texts in A17.

³⁵ Although the sources attribute plural worlds to Anaximander, they may be confusing states of the world with the world: Kahn 1960, 46–53, cf. Cornford 1934. On the religious language of the Presocratics, see Deichgräber 1933. The religious dimension of *to apeiron* is stressed by Sinnige 1971, 1–14.

³⁶ *Iliad* 8.18–27; 1.396–406.

³⁷ *Theogony* 886–900; though he is also powerful with his thunderbolts: 687ff.

³⁸ *Theogony* 521–5, 565–616; *Works and Days* 50–105. Debate continues about how amoral Zeus is in the administration of justice, but all parties concede that Zeus is seriously concerned with his personal honor: Dodds 1951, chs. 1–2; Adkins 1960, chs. 2–3; Lloyd-Jones 1983, chs. 1–2; Vlastos 1975, 10–18.

With Anaximander, by contrast, “it is essential to remember that the ‘justice’ and ‘reparation’ of fragment 1 operate simply through the self-regulative periodicities of a mechanical equilibrium.”³⁹ Though there is much more we need to say about Anaximander’s theory, we can note at the outset that the kind of regulation that the boundless seems to exercise is an impersonal one that is based on lawlike cycles rather than a personal one based on arbitrary interventions.⁴⁰ To assign divine names to the boundless is thus not merely to rearrange the pantheon, it is in part to reconceive what it is to be divine and how divinity operates.⁴¹ In fact, the boundless seems to steer all things through enforced regularities rather than through the willful use of powers such as thunderbolts and earthquakes. But if that is the case, the influence of the boundless can recede into the background as we study the regularities themselves which become the foreground of research. The kind of divinity Anaximander recognizes seems compatible with natural order.

1.2 Anaximander’s Project as a Scientific Program

Anaximander’s explanation of the world can be seen as providing a pattern for future explanations. It exemplifies a kind of project for anyone who wishes to engage in naturalistic explanation of the world. If we look forward to the last of the Presocratics, we see the project embodied in Anaximander’s account still in use. A rough contemporary of Socrates, Democritus applied the atomic theory of his predecessor Leucippus to account for the natural world.

(1) Everything in the world comes from microscopic atoms and empty space.⁴² (2) Atoms have an everlasting and irreducible motion by which

³⁹ Vlastos 1952, 115.

⁴⁰ “The notion that the primary physical elements are alive and divine is as old as Greek philosophy itself. While we can connect the living earth and air of the early cosmologists with earlier ideas of a divine Gaia in Hesiod, for instance, the more important point is again that in cosmology earth and air, while still divine, are not personal gods. They have no will. They are left with one and only one of the properties of the living, namely the capacity for self-movement” (Lloyd 1975, 203).

⁴¹ “Anaximander’s *apeiron* is in no way conscious or personal and, if it guides all things, it does so in no voluntary sense. . . . If [the lawlike control of the boundless] is to be considered in relation to theology, it must be admitted to be a complete rejection of all that was traditional in Greek religion. It is the denial that natural order can be suspended by any supernatural being or force, the denial in fact that any supernatural being can exist, and the assertion that, if the divine means anything at all, it can mean only the system of nature ordered according to infrangible law” (Cherniss 1951, 327). It is possible that predicates associated with divinity were more fluid than at a later time; cf. Clarke 1995 on Thales.

⁴² Diogenes Laertius 9.30 = Leucippus A1.

they dart about in the void. At certain times and places in infinite space, atoms by chance collide in such a way as to create a whirling motion that draws in more atoms. A kind of cosmic storm takes place in which a membrane is produced about the whirling mass. (3) Inside the membrane, the vortex motion sifts different kinds of atoms into different places, forming the great masses of the world. A flat earth disk forms in the center which gradually dries out. The heavenly bodies are dried out and ignited by friction.⁴³ (4) The earth takes shape with the seas in its hollows as residual water from the swampy proto-earth, with the heavenly bodies taking their customary place and order.⁴⁴ (5) Living things emerge from the moisture, come to inhabit land, and form the present biosphere. The human race emerges, develops language and culture, and dominates the earth.⁴⁵ (6) The multifarious phenomena of heaven and earth are explained by the actions of different kinds of atoms in different sorts of arrangements.⁴⁶

In this account (A) the atoms and empty space, alleged basic features of the world, account for all events, processes, and things. (B) Democritus's account explains all natural phenomena, now including not only events of nature but even human culture and history, which are subsumed under natural processes. (C) Democritus constructs a closed system of natural explanation in which one set of items (the microscopic ones) explains all others. (D) Explanation takes place as a reduction of things and events to pieces of matter in interaction with one another. (E) Democritus writes numerous prose treatises to develop his theory, producing a new vocabulary for some of his ideas.⁴⁷ (F) He uses examples from everyday experience to illustrate and support his theory.⁴⁸

The content of the account and the method by which it is arrived at are evidently the same as in Anaximander. The one striking variation we find is that in Democritus the explanantia are nonperceptible and indeed in principle nonperceptible. Democritus posits certain unseen elements from which the world is theoretically constructed, without being able to appeal to the explanantia as familiar items of our environment. (Anaximander did start with an original source that was somewhat mysterious: the boundless, and some generative material that arose from this. Hence there is a sense in which he too depends on imperceptible posits. But Anaximander appears to explain events in the present cosmos in terms of famil-

⁴³ Diogenes Laertius 9.31–2.

⁴⁴ Diodorus Siculus 1.7.1–2.

⁴⁵ Ibid. 7.3–5, 8.1–7.

⁴⁶ E.g., lightning and thunder in Leucippus A25, Democritus A93.

⁴⁷ von Fritz 1938, 12–38.

⁴⁸ E.g., Democritus B164; for a recent account of the scientific character of Ionian philosophy, see Hussey 1995.

iar materials.) But even though Democritus's first principles are not sensible objects, they are allegedly natural beings, to be understood by analogy with everyday particles of matter.

Perhaps there is some value in making a further comparison to present-day scientific explanation. (1) More than thirteen billion years ago, a sudden explosion of energy occurred. (2) In the first few instants, a great profusion of subatomic particles was produced, leading to the formation of protons, neutrons, and electrons. The laws of nature we are now familiar with began to apply to the new matter. (3) About three hundred thousand years after the initial burst of energy, protons, neutrons, and electrons joined to form hydrogen atoms. In places hydrogen gathered together, drawn by gravity, to form ever more dense clouds of gas, some of which collapsed into dense spheres which began to produce energy by nuclear fusion, generating helium nuclei as a by-product. In time moribund stars exploded as supernovas and novas, generating a wide range of elements by fusion, which were scattered by the force of the explosions.

(4) Galaxies, systems of stars, formed throughout space, held together by the forces of gravity, often with a massive black hole in the middle. One galaxy, the Milky Way, formed. Twenty-eight thousand light-years from the center, a cloud of dust and gas with the right ratio of metals to gases contracted to produce a middle-sized yellow star, the sun, surrounded by a disk of matter. The matter collected into planets, the third of which, with the right mass and distance from the sun, held an atmosphere and a sea of liquid water. About four and a half billion years ago, the impact of a planetary body the size of Mars sent debris from the planet into orbit; the ejecta coalesced by gravity into a satellite.

(5) Lightning strikes in the sea, rich in hydrocarbons, produced increasingly complex organic molecules, which gave rise to living cells, which evolved into multicellular organisms. Eventually mammals were differentiated from reptile ancestors. As a result of a devastating meteor strike sixty-five million years ago, most large reptile species were driven to extinction, and mammals emerged as the dominant life-form. In Africa hominids emerged among primates, and eventually homo sapiens appeared. Endowed with a large brain, members of the species developed language and culture and spread throughout the world, coming to dominate it and drive to extinction many species of fauna.

(6) All objects are constructed of molecules compounded of atoms, made of protons, neutrons, and electrons. Protons and neutrons, in turn, are composed of two kinds of quarks, while three fundamental kinds of force are carried by photons and bosons. By appealing to matter and the laws of physics, as well as laws of chemistry and biology, phenomena from light radiation to star formation to diseases to volcanoes to earthquakes can be accounted for.

(A) The explanantia now are various and complex, but they are all natural particles or elements. (B) A complex array of laws of nature accounts for interactions, from the quantum level to the redshift of stars. Laws make use of elaborate mathematical relationships. (C) Scientific explanation includes many subjects with different areas of research, but there is at least an assumption embodied in the Unity of Science principle, that a basic set of principles can ultimately account for all phenomena, however difficult it may be in practice to carry out the unification. (D) Explanations ultimately presuppose simplification from organisms to organs to cells to molecules to atoms to subatomic particles, which are themselves pieces of matter or of energy, operating according to basic laws of physics. (E) The many accounts of scientific research are composed in prose treatises giving empirical and mathematical justifications for inferences made. (F) Science draws its evidence from experience, now highly refined in the form of controlled experiments and observations aided by elaborate physical and conceptual instruments such as optical and radio telescopes, electron microscopes, and spectrosopes, mathematical formulas, and computer processing.

It would be naive to think of modern science as a straightforward successor to the theory of Anaximander. Before the twentieth century, scientists could not identify a determinate temporal beginning to our universe, or recognize that there were galaxies or quarks or black holes or many of the entities and events that now populate the standard account of science. There were major historical detours from the Ionian scientific program, advocated by Plato and Aristotle, which dominated the intellectual landscape until the early modern period.⁴⁹ Nor is modern science simply a revival of ancient models. Nevertheless, before there was modern science, there was Ionian philosophy, and the Ionian project formed, as we shall see, a *sine qua non* of all ancient science. And there has been an unbroken historical succession of physical theories from the Ionians to the present. Moreover, the vortices of Descartes and the atoms of Newton were echoes of ancient models from the Ionian tradition. Thus, while modern science is not a pure descendant of Ionian philosophy, Ionian philosophy remains a remarkable anticipation of modern science and unquestionably served as an inspiration and model to early modern scientists.

Anaximander's project, in any case, proved in the hands of his successors a program capable of endless development and, in light of its modern

⁴⁹ This is not to say that Plato and Aristotle were unscientific, or that they acknowledged no debts to the Presocratics, but that their conception of science in some key respects had less in common with modern science than did Presocratic conceptions. See Vlastos 1975 on Platonic science. Yet even in diverging from Presocratic methods, Plato roughly follows the scheme of a Presocratic cosmogony in his *Timaeus*, and Aristotle, himself ethnically Ionian, in many ways embodies the best principles of Ionian *historia*.

incarnation, productive of the greatest advances in knowledge the world has known. In a sense his private project has become the grand quest for knowledge of the world. In its conception it owes something to Hesiod's myths; but in its execution it draws on a wholly naturalistic method of describing and explaining the world. We may quibble about whether the Ionians were scientists. Certainly they had no scientific method per se, no adequate device for testing their own bold speculations or for adjudicating between competing theories. But that the program was in essence a scientific program is established by parallels to its modern counterpart. And a commitment to the program itself seems to have been the one essential ingredient of science as we know it. If this is right, the West had a scientific worldview before it had science, and the former was an indispensable precursor to the latter.

1.3 Toward an Understanding of the Ionian Tradition

1.3.1 *Questions of Classification*

Thus far I have spoken very generally about an Ionian tradition; I have not attempted to define the term or to delimit the Ionian tradition from any other movement, school, or tradition. In fact, it is difficult to identify this or any other particular movement among the Presocratics, largely because the interpretive tradition gives a muddled picture of the various schools and stages of thought. Aristotle laid the foundations for historiography of Presocratic philosophy by his at least partially historical account of them in *Metaphysics* I. His aim in that work was not to give a general characterization of Presocratic philosophy but to show that there are just four causes, namely the ones Aristotle himself recognizes. He set out to demonstrate this by showing that his predecessors gradually came to make use of at least some of the four causes. In the process of showing how the causes were used by the Presocratics, Aristotle provided a story of their development from one very specialized point of view. Aristotle's story became the basis of Theophrastus's multivolume history of doctrines, which in turn became the bible of Presocratic history throughout antiquity. Aristotle's own views were not completely original but apparently drew on previous attempts to pigeonhole early philosophers.⁵⁰ The interpretation of Presocratic philosophy presented by Aristotle and expanded by Theophrastus has severe limitations, as has been emphasized by twentieth-century commentators.⁵¹ Yet paradoxically, it continues to

⁵⁰ As shown by Snell 1944; Classen 1965; Patzer 1986; Mansfeld 1990, 22–83.

⁵¹ Cherniss 1935 provided a detailed survey and argument for Aristotle's failures; McDiarmid 1953 extended the criticisms to Theophrastus. Guthrie 1957 attempted to defend

provide not just the data but also the principles of contemporary interpretation, as we shall see.

What emerged from ancient accounts was a view that there were several schools and movements of philosophy (which overlap each other, as we shall see shortly). The Ionians (consisting in the first place of the philosophers of Miletus) were *physiologoi*, or natural philosophers who focused on cosmology and explained the origin of the world in terms of some fundamental matter. The Pythagoreans appealed to the formal cause and said that everything was number. The Eleatics (Xenophanes, Parmenides, Zeno, and Melissus) argued for the One as against the many appearances and rejected any kind of change. The pluralists (chiefly Anaxagoras, Empedocles, Leucippus, and Democritus) argued for a plurality of fundamental beings that would allow for change and save the appearances from Eleatic arguments. Heraclitus was an important but isolated Ionian thinker who argued for universal flux and the identity of opposites and consequently transgressed the Law of Non-contradiction.

The one thing that twentieth-century historiography added to this story was a clear recognition that Parmenides was the great watershed of Presocratic thought: his arguments forced some kind of a fundamental reaction to his criticisms. Unfortunately, who he was arguing with and why remained unclear, indeed became more uncertain with time. From the late nineteenth to the mid-twentieth century, the role of the Pythagoreans was emphasized: there was an important Pythagorean school in southern Italy from the late sixth century, according to the story, which dominated the philosophical scene of the western Greeks. Parmenides and even Zeno were reacting to members of this school, arguing for their One against the Pythagorean Many, embodied in a kind of mathematical atomism (according to one version).⁵² In the fifties and sixties this picture collapsed: there was no evidence for such a Pythagorean doctrine—it was all a mirage generated by the wishful thinking of scholars.⁵³ This left Parmenides with no dialectical opponent to criticize. About this time analytic philosophy diverted attention away from the historical and dialectical situation to questions about the semantics of the verb “to be,” and so the question

Aristotle, but his argument is weak: Stevenson 1974. Recently Collobert 2002 has reexamined the question, but she concludes that Aristotle is less than a historian of philosophy. While we are deeply indebted to Aristotle for the information he provides, and while recognizing Aristotle can often distinguish the views of a predecessor from his reactions to them, we need to be careful of his global interpretations. In this study I shall give reasons for thinking Aristotle’s overall reading of Presocratic thought is untenable.

⁵² Sometimes called “number-atomism.” See ch. 6 below.

⁵³ E.g., Vlastos 1953b, a review of Raven 1948, which sees Eleatic philosophy as closely connected to Pythagoreanism; and Burkert 1972 [1962].

was left unanswered and often unaddressed.⁵⁴ There was near unanimity about what happened after Parmenides: the pluralists saw in Parmenides and his followers the threat to scientific philosophy and desperately developed pluralistic schemes designed to allow for phenomenal change without presupposing coming to be and perishing, which Parmenides had ruled out. Unfortunately for them, they ignored other equally damaging arguments against differentiation and any kind of change in general, which precluded the possibility of phenomenal change.

Although today we can claim to have fairly coherent pictures of individual Presocratic philosophers, the details of how philosophy developed in the sixth and fifth centuries BC remain obscure. Once scholars had rejected Pythagoreans as the dialectical targets of the Eleatic school, they lost any direct link between the early Ionians and the rest of the tradition. Who were the Eleatics reacting to—if anyone—and why? On the other side of the divide, why were the natural philosophers after Parmenides so helpless and inept at replying to him?

The obvious place to look for developments in the Presocratics is in the realm of what Aristotle called their causes and principles. According to Aristotle, the Ionians (or most of them) adhered to Material Monism, a doctrine which posited one kind of matter—for instance, water or air—as the source and essence of the world and everything in it. Not only did the world arise *from* the one substance in the distant past, but also all the different stuffs of the world were always composed *of* that substance. For it was the only substance in the world, all other alleged substances being merely modifications of the one stuff. After Parmenides, virtually all the natural philosophers are pluralists, who posit of plurality of stuffs or elements, which combine to form the features of the world. Thus we have a kind of ontological shift that takes place between the pre-Parmenideans and the post-Parmenideans. Aristotle, however, did not exploit this possibility but undermined the scheme by suggesting, sometimes at least, that Anaximander was to be classed with the pluralists because he relied on contraries to make up the stuff of the world and by identifying the post-Parmenidean figure Diogenes of Apollonia as a Material Monist.⁵⁵

Although some leading modern interpreters have proposed alternative ontological schemes, the majority still ascribe Material Monism to the early Ionians, or at least to Anaximenes and Heraclitus.⁵⁶ But modern adherents of the traditional view have not resolved the problems of inter-

⁵⁴ Starting with Owen 1960.

⁵⁵ He is ambivalent about Anaximander, whom he sometimes treats as a monist, sometimes as a pluralist, e.g., *Physics* 187a12–23, where lines 12–15 seem to allude to him as a monist (cp. *On Generation and Corruption* 332a19–25), 20–23 refer to him as a pluralist. Diogenes is classified as a monist like Anaximenes, *Metaphysics* 984a5–7.

⁵⁶ Perhaps most forcefully Barnes 1982, chs. 2–3.

pretation any more than did Aristotle. Indeed, modern interpretation is still surprisingly dependent on the schemes of Aristotle and Theophrastus. For all their advances in the study of individual philosophers, interpreters of the late twentieth century have been conservative to a fault. Even some of the most novel recent interpretations of details have been advanced within an old-fashioned, even reactionary, framework of interpretation.⁵⁷ In light of gaps and deficiencies of the standard interpretation, I believe it is time to reconsider the development of Presocratic philosophy. The position I will argue for in the present work is not original, but can be seen as a revival (with some significant modifications) of a classical interpretation of Harold Cherniss, reasserted in a revised form by Michael Stokes⁵⁸—an interpretation whose time has come to be taken as the best account of the data.

The set of interpretations proposed in the twentieth century is sufficiently unified in its overall assumptions and its continuity with traditional interpretations that we may call it the Standard Interpretation of Presocratic philosophy. I take it that this view comprises the following claims:

The Standard Interpretation

1. The early Ionian philosophers, or some subset of them, were Material Monists.
2. Parmenides attacked the cosmological program of the Ionians by attacking the foundations of their program.

⁵⁷ In their preface to the second edition of KR (= KRS), Kirk and Schofield say, “There has been a spate of publications on the Milesians, Xenophanes and Heraclitus over the last quarter-century, but the effects have been minor compared with those of work on Pythagoreans and Eleatics, and on Empedocles” (x); consequently they made only minor changes in the first part of the book. While this remark correctly describes the received opinion, it also indicates how impervious scholarship has been to several radical criticisms that have been made of explanations of early Ionian philosophy. Barnes 1982, in many ways the most philosophically sophisticated book on the Presocratics in recent times, is most innovative in treatments of arguments and details. In areas of global interpretation, however, such as of Milesian theory, Heraclitus’s philosophy, and the pluralists’ response to the Eleatics, Barnes follows traditional, even Aristotelian, models almost slavishly, as will be pointed out in subsequent chapters. For more recent reaffirmations of the standard view or parts of it, see Wright 1995, 78–79; Schofield 1997, 68; Taylor 1997b, 209; Hankinson 1998, 19–20; Algra 1999, 57–58.

⁵⁸ Cherniss 1935; Cherniss 1951; Stokes 1971. My account of Ionian physical theory is closer to that of Stokes than Cherniss. But Stokes’s account loses some force because he rejects Heraclitus as a link between the Milesians and the Eleatics, which Cherniss relies on; I shall defend a view like Cherniss’s at the beginning of ch. 6. Stokes also fails to give a positive characterization of Milesian theory. My account of the pluralists’ relation to the Eleatics, however, will be fairly different from Cherniss’s. I stand by Cherniss’s conclusion concerning the early Ionians: “So we find no ‘material monism’ in the Ionic theories all of which Aristotle reduced to this formula” (1935, 382).

3. The post-Parmenidean pluralists tried to rescue the cosmological program from Parmenides' attack by ascribing Eleatic properties to a plurality of beings.
 - a. The early pluralists were unsuccessful because they did not provide a theoretical foundation for plurality or change.
 - b. The atomists were successful because they denied a key principle of the Eleatics.

It is my contention that (1) is false, that (2) has not been and probably cannot be connected to (1) by proponents of the Standard Interpretation, and that (3) seriously misrepresents the historical situation: contra (a) there is no evidence that the early pluralists were even trying to answer Parmenides' attacks; contra (b) the case typically made by the Standard Interpretation should entail that the atomists were even more unsuccessful than earlier pluralists.

One general problem for the Standard Interpretation is the scope of the theory: how much does it explain? It seems to leave out at least three major cosmologists as irrelevant: Xenophanes, Heraclitus, and Diogenes.⁵⁹ Xenophanes and Heraclitus are philosophical dead ends, while Diogenes is a throwback. On my reading, all three will be integrated as important voices in the ongoing debate. In general, according to my interpretation, Parmenides' criticisms are all the more telling because they address not Material Monism but another type of theory; on the other hand, his criticisms are taken as constructive criticisms by the early pluralists, who see themselves as disciples of Parmenides, so that there is significant continuity between the early cosmologists and the later cosmologists. Parmenides plays a pivotal role but not the role of spoiler he is traditionally accorded.

Against the Standard Interpretation, I shall offer something like the following (in a point-by-point contrast with the Standard Interpretation):

Revisionary Interpretation

1. The early Ionian philosophers were generating-substance theorists (to be explained later).
2. Parmenides attacked the cosmology of the Ionians by attacking their ontology and theory of change.

⁵⁹ In the present *status quaestionis* Pythagoras gets left out of both the Standard Interpretation and my own, for want of evidence that he had a cosmology. The Pythagorean Philolaus, however, fits into my scheme, though I shall not focus on him. Philolaus has increasingly been accepted as the source of early cosmological reports about the Pythagoreans: Burkert 1972, chs. 3–4; Huffman 1993 (see further sec. 6.1 and n. 16). There have been attempts to rehabilitate early Pythagorean cosmology independent of Philolaus: Zhmud 1997; Kahn 2001, with Kahn 1974, but I remain skeptical. Even if Pythagoras had a cosmology, it must have been indebted to Ionian models in a significant way (see Zhmud 289, 292).

3. The post-Parmenidean pluralists saw themselves as followers of Parmenides, accepting his cosmology as paradigmatic.
 - a. The early pluralists carried out the program implicit in the second half of Parmenides' poem.
 - b. The atomists modified Parmenides' assumptions to accommodate later Eleatic challenges, but continued to work within an Eleatic framework.

The aim of this book will be to explicate the several theories of the Ionian philosophers, and to elucidate the relationships among the philosophers of the Ionian tradition and between them and their Eleatic critics. Yet I shall maintain that the Eleatics are, in a curious way, also heirs of the Ionian tradition, and connected with that tradition in a more complex way than is usually recognized.

One major consequence that emerges from this line of interpretation, if it is correct, is that the Ionian tradition is *the* great tradition of Presocratic philosophy. Even so harsh a critic of cosmology as Parmenides feels bound to produce a cosmology (or anti-cosmology) of his own—which willy-nilly becomes a paradigmatic cosmology in its own right. The Pythagoreans become participants in the conversation only by introducing Pythagorean religious elements into an Ionian-style cosmology—as does Empedocles⁶⁰—or by founding a cosmology on Pythagorean-style principles—as does Philolaus. Later philosophers are free to introduce new religious, psychological, or ethical elements, and even to find new kinds of fundamental entities, but they must work within the framework of a cosmology—they must make Anaximander's project their program of research. There are, in this vibrant and creative conversation, anti-cosmologists. But they remain the minority view, the Loyal Opposition. Later cosmologists employ ever more sophisticated ontologies and achieve modest but important scientific advances in an ever-expanding domain of research. They always work within the Ionian program.

I shall argue, then, that when we replace inadequate interpretations, we may see the Ionian tradition as pursuing a common program by applying first one, then another system of explanation. Roughly, the two schemes of explanation embody two successive paradigms, in the terminology of Thomas Kuhn, for research. Perceived failures in the former—failures of theory rather than of fit between theory and fact—force the abandonment of one system and the adoption of another. We can, I shall argue, describe a kind of progress from the earliest to the latest cosmologi-

⁶⁰ Kingsley 1995, 2002 rightly argues for the importance of the religious dimension in Empedocles—a feature often downplayed by scholarship. But religion is integrated with cosmology in the Ionian style, as has become increasingly apparent with the publication of the Strasbourg Papyrus: Martin and Primavesi 1999.

cal theories. And to recognize progress is to allow the possibility that even in its infancy, the scientific program of the West was capable of making advances and in some measure of justifying its own existence. But to test these claims, we must look at the details of Ionian explanations and the controversies they generated.

1.3.2 *The Ionian Tradition Characterized*

One piece of unfinished business remains. I have yet to say what I mean by the Ionian tradition. Several schemes have been imposed on the Presocratics since ancient times. One is a geographical one, along a north-south axis or meridian: the philosophers from the East, especially from Ionia proper (roughly the Aegean coast of Asia Minor), but including the Ionian language and ethnic group (e.g., Democritus of Abdera, on the coast of Thrace in northern Greece), are cosmologists; the philosophers from the West—southern Italy and Sicily—are religious or metaphysical thinkers, for instance, Pythagoras, Xenophanes, Parmenides, and Empedocles.⁶¹ Second, there is a numerical ontological scheme: monists vs. pluralists, so that, for instance the Ionian monist Thales would be classified differently than the Ionian pluralist Anaxagoras.⁶² Third, Aristotle sometimes divides his predecessors into natural philosophers on the one hand, and anti-natural philosophers on the other.⁶³ The latter class is exhausted by the Eleatics, while the former consists of roughly everyone else. Finally, there is a classification strictly by local schools: the Milesians, the Pythagoreans, the Eleatics.⁶⁴

Each scheme brings with it certain insights. The geographical scheme allows us to see certain differences of content and emphasis, and suggests cultural and historical reasons as their basis. The ontological scheme allows us to group philosophers by their principles, and hence by their philosophical commitments. The division into cosmologists and anti-cos-

⁶¹ Diogenes Laertius 1.13–15. A distinction between Ionic and Italian schools is a major theme of Diogenes: Mejer 1978, 51. KRS follows this scheme in structure, even more closely than did KR, as can be seen in their respective tables of contents. Actually the notion of schools, *haireseis*, was originally applied only to those institutions organized by the Socratics or later (Diogenes Laertius 1.18), and was only gradually extended to the Presocratics (see Mansfeld 1992, 23–26).

⁶² Plato *Sophist* 242c–e; Aristotle *Physics* 184b15–25; Isocrates *Helen* 3, *Antidosis* 268. Aristotle's scheme is further complicated by Theophrastus; see Wiesner 1989.

⁶³ Aristotle *Physics* 184b25ff.

⁶⁴ This scheme was followed especially by the composers of successions of philosophers, starting with Sotion or perhaps Ariston of Keos, both Peripatetics: DG 147; Wehrli 1967–1969, 65; Burnet 1930, 37. There is a further division of philosophers into dogmatists and skeptics, presumably made by members of the latter group (Diogenes Laertius 1.18); it does not have a strong application to Presocratic philosophy.

mologists allows us to classify philosophers in terms of their most fundamental project. And the school designations allow us to group philosophers in terms of their participation in an intellectual community.

Each scheme, however, also brings with it its own problems and obscurities. The geographical scheme glosses over complex geographical relations. Pythagoras of Samos and Xenophanes of Colophon migrated from Ionia to the West. Are they then westerners or easterners? Traditionally the former is classified as a Pythagorean, the latter as an Eleatic. Melissus of Samos in Ionia is classified as an Eleatic, although we do not know that he ever left his native Ionia. Empedocles of Acragas in Sicily has much in common with the Ionians, although he is also indebted to the Eleatics and Pythagoreans. The ontological scheme breaks down when we see that Aristotle seems to treat Anaximander sometimes as a monist, sometimes as a pluralist. Xenophanes can be read as a monist, a dualist, or a pluralist. And we find no correlation between geography and ontology: the easterners Thales, Anaximenes, and Diogenes are allegedly monists, but other easterners—Anaximander (perhaps), Anaxagoras, and Democritus—are pluralists, and so on. The distinction between cosmologists and anti-cosmologists breaks down when we realize that Xenophanes, allegedly an anti-cosmologist, is arguably a cosmologist, while Parmenides the anti-cosmologist devotes most of his poem to developing a cosmology. The school classification projects onto the Presocratics institutional relationships that can be documented only from the fourth century on.⁶⁵ It further creates problems by sometimes combining figures who arguably never associated with each other, such as Xenophanes, Parmenides, Zeno, and Melissus. Of these four Eleatics, only the second and third are likely to have known each other. School successions regularly combine philosophers who, for chronological reasons, demonstrably could not have studied together. For instance, Anaxagoras and Diogenes of Apollonia are alleged to have been students of Anaximenes; but both students, according to our chroniclers, were born after their teacher's death.⁶⁶ Meanwhile, important thinkers such as Heraclitus are left out of the schools.

⁶⁵ The one solid piece of information that seems to point in the direction of a teacher-student relation is Alcmaeon B1, which mentions three disciples. Alcmaeon was a physician as well as a philosopher, and disciples may have been apprentices. Problems with viewing the Ionians as a school are laid out already by Grote 1881, 2.217: "Writers, ancient as well as modern, have professed to trace a succession of philosophers, each one the pupil of the proceeding, between these two extreme epochs [from Thales to the time of Socrates]. But the appellation is in truth undefined and even incorrect, since nothing entitled to the name of a school, or sect, or succession . . . can be made out."

⁶⁶ Diogenes Laertius 2.6; cf. Hippolytus *Refutation* 1.8.1. According to Apollodorus, Anaximenes died in the sixty-third Olympiad, 528–25 BC (DL 2.3), while Anaxagoras was born in the seventieth Olympiad, 500–497 BC (DL 2.7). Diogenes of Apollonia "lived around the time of Anaxagoras" (DL 9.57), but must be younger still.

Thus the traditional classes do not seem to be self-consistent or to reinforce each other.

Is there, then, any hope of meaningful classification of the Presocratics, and is any meaning to be assigned to terms like “Ionian”? The one scheme that seems to work fairly well is the most modern: the distinction between pre- and post-Parmenideans. This is a historical-dialectical distinction that does seem to account for differences in approach according to the thinkers’ location in historical space. As to the term “Ionian,” it admits of expansion. If we include Xenophanes and Heraclitus with the Milesians, we see similar patterns of explanation—or so I shall attempt to show. And after all, both Xenophanes and Heraclitus are from Ionia, and both are pre-Parmenidean.⁶⁷ The early (sixth-century) Ionians do embody an approach to cosmology that has a chance of being in some sense unified and hence instructive to us. And if we can establish that Parmenides is reacting to *their* style of cosmology, instead of to some shadowy Pythagoreans or to no one at all, we shall have established an important dialectical link for the history of philosophy.

But of course, after Parmenides there were cosmologists too. Barnes has dubbed their theories “neo-Ionian systems” in a happy phrase.⁶⁸ The authors of these theories include Ionians as well as non-Ionians (most notably Empedocles). These neo-Ionian thinkers continue, in broad outlines, the project of the early Ionians. To that extent, the fifth-century cosmologists are the intellectual heirs of the sixth-century cosmologists, who happen to be Ionians. Accordingly, I shall refer to those who pursue the goal of rational explanation of the cosmos, in either century, as adherents of the Ionian tradition. By calling it a tradition I do not wish to commit myself to the school scheme; by calling it Ionian I do not wish to commit myself to a geographical scheme. I wish only to pay respect to the great intellectual flowering of the sixth century that established in Ionia for the first time a program of the sort that could be emulated and pursued ever after by thinkers making similar assumptions.

One further caveat: it is a problem of philology how soon the term *kosmos*, “order” came to mean “world.” According to different scholars, the latter sense could occur as early as Anaximander or as late as Plato.⁶⁹ But it is a fact that from Anaximander on, philosophers were attempting to explain the cosmos, whether they had a word for the world or not. Since

⁶⁷ The case for Heraclitus is controversial; I will argue for this point in ch. 6.

⁶⁸ Barnes 1982, 305 et passim.

⁶⁹ For the early date, Kranz 1938, 433; Kahn 1960, 188; for the late, Finkelberg 1998a. See Diller 1956; Kerchensteiner 1962; Vlastos 1975, ch. 1. In any case *kosmos* is thematically linked with the natural world, at least from the late sixth century: Heraclitus B30, Diogenes B2, in both cases marked by a demonstrative apparently referring to the actual state of affairs.

my thesis focuses on the type of explanation the early cosmologists used rather than on the language they used to describe that type of explanation, my thesis does not depend on the resolution of the philological question.

It is a contingent fact of history that a new style of explanation was invented in Ionia in the sixth century BC. But it is precisely the ability of this style of explanation to be exported, adapted, continued, and expanded that made it so valuable. A refugee from the Persian invasion of Ionia, Xenophanes could carry it in his head, and embellish with it the poems he recited to kings and symposiasts. It guided a seaman from Massalia (Marseilles) on the first recorded Atlantic voyage by a Greek, and it guided a historian from Ionian Halicarnassus on his voyage up the Nile in the mid-fifth century BC.⁷⁰ By such modest means it seems to have quickly traveled the length and breadth of the Mediterranean, wherever learned Greeks gathered and talked about the nature of things. It transcended schools and geographical regions, and ultimately historical epochs as well: decades and centuries, and, arguably, millennia. Indeed, it has become a possession for all time. Perhaps what gave the new style of explanation its impetus was the very process in which it was embedded: more than a set of results or a final conclusion, Ionian inquiry embodied an ongoing program of research. The program generated successes and apparent successes that justified its continued pursuit.

Ultimately, driven by a promising program of research, the Ionian tradition defined the world as a natural realm governed by lawlike regularities. The program promised to make the events of the natural world comprehensible in all their details, and to make the world itself an object of knowledge. The first steps in the tradition can be traced in Anaximander, to whom we now turn.

⁷⁰ A striking (but little-known) example of the early diffusion of physical theories is that of the explorer Euthymenes of Massalia, who seems to have used Thales' theory of the Nile floods in his observation of the waters of a major river on the Atlantic coast of Africa (perhaps the Senegal River), which he mistook as the source of the Nile (Seneca *Natural Questions* 4A.2.22). Euthymenes' date is uncertain, but could be as early as 530 BC: Jacoby 1909; Cary and Warmington 1929. Ionian theories guided Herodotus's inquiries in his own visit to the Nile (*Histories* 2.19–29); see Graham 2003c.