Early Greek Philosophies of Nature

Andrew Gregory

BLOOMSBURY ACADEMIC
LONDON • NEW YORK • OXFORD • NEW DELHI • SYDNEY

1

Methodological Issues

As methodological issues will be crucial for this book, I want to discuss some of the key aspects in this first chapter. In particular I want to start with historiography, that is, how we approach doing the history of early Greek ideas on nature. As I will challenge the idea that any early Greek thinker was a mechanist, what assumptions are therefore in play and why have some scholars seen mechanism in early Greek thought? I also want to argue for some important intellectual space between what has direct affinity with modern science and what has been termed 'the primitive'.[1] I will look at how terms such as mechanist have been defined, and argue there is no one agreed definition; rather there is a wide range of views. Some Greek terms need examination as well, most notably the standard term for nature, *phusis*, but also *kubernan*, to steer, and *kratein*, to control. I will also question why scholars have taken supposed affinities between ancient science and seventeenth-century mechanical philosophy to be so important. Finally, I have something significant to say about Plato and early Greek thought. I argue that too stereotypical an approach to Plato in general and the *Phaedo* passage known as Socrates' autobiography in particular gives an account of thought prior to Plato that is too binary and inflexible. A less rigid account of Plato's reactions to his predecessors, which is supported by other passages in Plato, reveals interesting information about early Greek thought on nature.

Early Greek mechanistic thought?

One important argument of this book will be that there has been a tendency to overestimate the extent to which early Greek philosophies of nature can be described as 'mechanistic', along with an overestimate of how plausible and effective the 'mechanistic' interpretations would have been in context. I take 'mechanistic' quite broadly here, encompassing views on ontology, causation,

explanation, analogies and natural laws. The corollary is that we have underestimated the extent to which these philosophies of nature were committed to other modes of explanation and ontologies, and that we have underestimated, and indeed underexplored, how plausible and good these philosophies would have been in context.

It is important here not to privilege mechanistic interpretations in three senses. First, one approach to early Greek philosophies of nature has been to seek affinities with modern science. The view, largely tacit, is that the deeper or more wide-ranging these affinities are, the higher our evaluation of early Greek science will be. Hence there has been a drive to find affinities between early Greek thinkers and either the mechanical philosophy of the seventeenth century and after, or modern mechanistic views. Second, some aspects of the mechanistic view, particularly relating to how we frame natural laws, have become widely and generally accepted. It is important that we do not treat key assumptions here as atemporally evident, or in some sense natural, and everything else as inferior to or as a deviation from these supposed atemporal truths. Third, we must recognize that the mechanistic view has undergone development and has had periodic crises of plausibility. So, in the eighteenth century the mechanical philosophy struggled for plausible explanations of biological phenomena recently discovered with the microscope until more sophisticated modelling techniques were developed. It is critical to recognize that ancient mechanistic views lacked sophisticated modelling, and opposition to them was not wholly based on issues of teleology or theology but could be based on issues of plausibility as well.

This book will argue that there is an important sense in which the early atomists, Leucippus and Democritus, often taken to be mechanists, were in fact not mechanists. Materialists, certainly, with an ontology of atoms and void, what is and what is not. However, there is a difference between materialism and a mechanical interpretation of materialism. If we look at the analogies the early atomists used, they did not use mechanical analogies, they did not liken the world to a machine, but used biological, human, agricultural and maritime analogues instead.

Two arguments against early mechanistic ideas do not interest me.[2] One is that there was some form of disdain for the practical in the early Greek thought. Whether there was such a disdain or not, I would contend that a move to a mechanistic view of the world is not a simple, natural and straightforward consequence of a practical engagement with the world. The other argument is that the early Greeks saw mechanics as in some way contrary to nature or in

some sense not part of what they conceived of as the investigation of nature. Recent work has debunked this view.[3]

Modernization?

I take this issue about affinities and mechanistic thought to be one within a broader phenomenon. In the history of science seeking affinities occurs more broadly, and one can see this process at work in the history of philosophy and in the history of literature too. The problem is not so much seeking affinities on their own but, as von Staden has argued, seeking affinities and eliding differences, or privileging any perceived affinities.[4] There are several considerations to be balanced here. One is historical generosity towards the subject, which will lead us to look at possible affinities. On the other hand, we must be conscious of the fact that ideas do have a history and it is possible to attribute them anachronistically. Even if one is a strong realist about those ideas (so they always exist), human realization of them is a separate issue. I have argued elsewhere that the pursuit of scientific affinities can be misleading and indeed counterproductive.[5] So with Anaximander, trying to make him 'the first Darwinist' conceals the interesting work he was doing in zoogony,[6] recognition of which makes him a less 'modern' thinker, but paradoxically much more coherent and interesting, and one more in tune with the ideas of his time.

I bring up these issues because I have some things to say about Homer and Hesiod that may be controversial. I will argue that there is an important sense in which neither Homer nor Hesiod had philosophies of nature. By this I mean that they had no term for nature, nor did they have any conception of or any term for what is beyond or contrary to nature. Homer's Circe has been hailed as the first witch in the Western literary tradition. However, neither narrator nor characters in the *Odyssey* treat her as a witch, and she does nothing different in kind to other gods and goddesses. This issue is important as it relates to Homer and nature. Is there a conception of beyond the natural to support the assertion of witchcraft? I argue there is not. The idea of Circe as a witch is an anachronistic imposition on Homer. There are other aspects of this phenomenon as well. I am concerned that translating *moira* (lot) as 'fate' can import inappropriate modern ideas to Homer. It is also unfortunate that debates about epistemology in Homer have centred on scepticism, a later idea for which Homer has no recognizable motivation, rather than looking at much more interesting issues of the Muses and the authority of the account given and what humans can know about the

gods and *moira*. Finally, I argue that the idea of a *historia*, an investigation or enquiry, is alien to both Homer and Hesiod. If we are going to talk in terms of *peri phuseōs historia*, an 'enquiry concerning nature', we need to understand that later thinkers generated both the notion of *phusis* and the notion of *historia*. Less controversial will be my rejection of the idea that the self-moving equipment of Hephaestus' workshop (*Iliad* XVIII, 414 ff.) and the self-steering ships of the Phaeacians (*Odyssey* VIII/ 555) were mechanical automata. This is a point worth mentioning to show that there can be interpretations of Homer that are too modern and too mechanistic, and a line needs to be drawn somewhere. The result of this process, applied to both poets and early philosophers and medical thinkers, is that we find an interesting engagement with the poets on issues of the generation and maintenance of order and on issues of epistemology as well.

Reflexivity

As I will point to some affinities between later developments and early Greek thought, there is an issue of reflexivity to account for. Indeed, if we think there is any continuity between the ancient investigation of nature and science, there must be such affinities and we need some affinities in order to be able to demarcate our subject matter from other ancient endeavours. It is not seeking affinities as such that is the problem, but doing so to the exclusion of dissimilarities, doing so within a Whiggish account of the history of philosophy or science, and doing so in a way which over-estimates the modernity of those affinities. I hope, being conscious of those pitfalls, to avoid them and to have a meta-level discussion of the nature and value of any supposed affinities, and as I have suggested above in relation to Anaximander, the depth of those affinities. It is also important to be conscious of attempting to be even-handed here. So one could produce an account that emphasizes the affinities between Homer/Hesiod and modern ideas (or the Babylonians/Egyptians etc.), without doing so for the Ionians, thus downplaying the significance of the Ionians and questioning any specific early Greek contribution to the conception of nature. Vice versa, and we have a huge gap between the Ionians and their predecessors and are forced to invoke a 'Greek Miracle' (see below) to explain such a rapid and significant change. While I will deny aspects of affinity to Homer and Hesiod (no conception of *phusis* or *historia*), I will also deny mechanism and evolution for Anaximander and will question other supposed or assumed affinities in Anaximander and other early Greek thinkers as well.

Parallels

I want to draw a parallel here with another episode in the history of science, which may help to illuminate some of the aims of this book. William Harvey (1578–1657) discovered the circulation of the blood around 1619. It used to be thought that Harvey did so because he advocated the 'progressive' new methods of the seventeenth century, the mechanization of nature and the mathematization of nature. This has now been shown to be conclusively false.[7] Harvey was an Aristotelian influenced by Renaissance trends in anatomy and philosophy and was an ardent anti-mechanist. He did one experiment that quantified blood flow, but if we look more closely the quantities were all significant underestimates and the argument was a qualitative one that no Aristotelian would have had any issue with.[8] Indeed, a parallel for this sort of experiment and reasoning can be found in Aristotle.[9] Importantly for this book, what might appear at first glance to be mechanical models of the heart and circulation turn out on closer examination to be no such thing. Harvey did not liken the heart to a pump, as has often been said, but to a pair of water bellows, and did so only in his lecture notes, while Aristotle had likened the lungs to a forge bellows. Much more prominent in Harvey is a macrocosm/microcosm analogy between the heart and the weather cycle. So as the sun heats and evaporates water, which subsequently cools and falls as rain, so the heart heats the blood and it is cooled in the extremities before returning to the heart. Aristotle had drawn a microcosm/macrocosm analogy between this weather cycle and the motions of the heavens. Harvey did liken the heart to a musket, perhaps a more promising mechanical analogy, but only in the sense that both heart and musket move too quickly to be observed properly by the naked eye, and not in the sense that the heart was a mechanical entity. It is important to look closely at what might appear to be a mechanical analogy and to examine exactly what was being got out of that analogy.[10]

The result of this re-appraisal of Harvey has been a richer, more interesting account of Harvey and one that gives us a much better understanding of his relation to the science of his time.[11] It allows us to understand why he chose a certain path of research, why he chose to express himself in certain terms, and why he chose a specific means of explaining the nature of the heart and the circulation of the blood. So with the early Greek thinkers, I hope that by giving up the attempt to impose mechanization (and to a lesser extent mathematization) on them we generate a richer account of them, that we can locate them better in their context and we can at least to some extent explain

why their fragments chose these particular examples and sought to explain them in this particular way.

I would also draw a parallel here with Unguru's seminal paper on the history of Greek mathematics, where he argues against the view that:

> Greek mathematics, especially after the discovery of the 'irrational' by the Pythagorean school, is algebra dressed up, primarily for the sake of rigor, in geometrical garb.[12]

Unguru also opposes the view that:

> There is nothing unique and (ontologically) idiosyncratic concerning the way in which ancient Greek mathematicians went about their proofs, which might be lost in the process of translation from the geometrical to the algebraic language; the main reason for this being that the ancient mathematical reasonings and structures *are* indeed substantially algebraic.[13]

Unguru's work has resulted in a much richer and contextually plausible account of Greek mathematics. I do not claim the parallels here are exact, but I would caution against taking analogies used by early Greek thinkers as mechanical analogies or mechanical analogies dressed up as something else and believe that something is lost if we do. The analogies used by Harvey, a strident anti-mechanist, were not mechanical, nor were they mechanical analogies disguised in the language of the time for whatever reason. It is also important to recognize that analogies used by the early Greeks had real work to do in their systems if we recognize the questions they were addressing. So returning to Harvey, the macrocosm/microcosm analogy was not just a fashionable, Renaissance means of describing the heart and circulation. Harvey faced two real and critical issues in relation to Galen's conception of blood flow. There are two types of blood in the body, in modern terms oxygenated and deoxygenated, or arterial and venous. If they are in one circulatory system, how do they rapidly and efficiently convert into each other? Secondly, if there is a rapid blood flow around the body, and major organs such as the lungs are part of the circuit, how can so much blood flow across major organs? Harvey resolved those issues using the macrocosm/microcosm analogy of the circulation and the weather cycle. Just as the sun heats water and turns it to vapour, so the heart heats the blood and changes it, and it is changed back by cooling in the extremities. Just as rain can fall on a hill and emerge as springs and streams on its way to the sea, so too can blood pass through the lungs. It is important that we recognize that the importance of the macrocosm/microcosm analogy for Harvey was marginalized in some accounts, and why that marginalization took place.[14]

Use of *kubernan* and *kratein*

One aspect of early Greek thought that has been marginalized is the use of the terms *kubernan*, to steer or to govern, and *kratein*, to rule, to have power over or to control. The Greek word *kubernan* primarily means to steer, as in being the helmsman, with other senses of to drive, guide or govern. The modern English 'govern' derives from *kubernan* via the Latin *gubernare*. I will take 'to steer' as my primary translation of *kubernan*, although as we will see in Chapter 4, that may underdo the full import of *kubernan*. In Greek sea practice, on larger ships the *kubernētēs* was the captain with someone subordinate to him actually doing the steering, and the *kubernētēs* had responsibility for the ship's safety. I will take 'to control' as my primary translation of *kratein* in cosmological contexts, without forgetting it may have other connotations. Typically, *kubernan* and *kratein* are used for the relationship that the *archē*, the primary or originating substance, has to the cosmos or to everything else. So, in Anaximander the *apeiron* steers all, in Heraclitus and in the Hippocratic *On Regimen* fire steers all, in Parmenides a goddess steers and in Diogenes of Apollonia air steers all. Plato's *Philebus* attests to a tradition of *kubernan* being used in such contexts. In Anaximenes air controls, in the Hippocratic *On Regimen* fire controls, in Heraclitus the divine law controls, in Xenophanes god controls, in Parmenides necessity controls, in the Derveni papyrus air controls, in Empedocles Love and Strife control, and the four elements take turns to control, in Diogenes of Apollonia air controls and in Anaxagoras mind controls. One reason that we can tie *kubernan* and *kratein* together is that some authors (a Hippocratic, Diogenes) use them in the same passage and use them virtually interchangeably.

It is worth doing a short version of this list – Anaximander, Anaximenes, Xenophanes, Heraclitus, the Hippocratics, the Derveni author, Parmenides, Diogenes, Empedocles and Anaxagoras – just to emphasize the large proportion of early Greek thinkers who used either *kubernan* or *kratein* or both. We need an enhanced understanding of what was meant by steering and control and how they related to the regularity and order of the cosmos. It is significant that ideas of steering and control are not even mentioned in important books such as Hankinson's *Cause and Explanation in Ancient Greek Thought*, Burnet's *Early Greek Philosophy* and Barnes' *The Presocratic Philosophers*.[15]

I will also be interested in the origins of the use of *kubernan* and *kratein*, as there are some interesting precursors in Homer and Hesiod. Homer in *Odyssey* and *Iliad* uses *kubernan* and its cognates but only ever in the sense of steering a ship. It is not used by Hesiod. The Phaeacian ships, which do not have human

helmsmen, but are capable of steering themselves may provide a model for how the cosmos can steer itself. Homer does use *agein*, to lead, for the gods leading like to like and both Homer and Hesiod use *ithunein*, to guide, for some actions of the gods. More critically, both Homer and Hesiod use the phrase *moira krataiē*, controlling *moira*. What I will argue here is that in Homer, the gods generate and maintain *moira*, and *moira* regulates the affairs of gods and humans. In early Greek thought, the attributes and roles of the gods can be seen to be transferred to the *archai*, the originating or principle substances. So the *archai* are, for example, 'deathless and unaging', and I argue they also take on the role of steering or controlling. I will also be interested in the move from *kata moiran* and *kata aisan* in Homer to the phrase *kata phusin*, according to nature. This transition has an interesting and important intermediate step in that both Anaximander and Heraclitus use the phrase *kata* (*to*) *chreōn*, which I will argue should be translated as 'according to what is proper' rather than 'according to necessity'. There are some further interesting *kata* … phrases in Anaximander and Heraclitus as well.

Intellectual space

One important theme for this book will be an attempt to escape binary assessments of ancient thought. By binary assessment here, I have in mind a bifurcation between assessing something as either modern or primitive, with little or nothing in between. It is critical to recognize that between modern views and what might be termed primitive or unreflective views of nature, there were many plausible alternatives that have subsequently been superseded. There is a need to investigate why these views were adopted and in particular what it was thought could be gained from these views. Take as a parallel here the centrality and stability of the earth for the early Greeks. This is not the modern view, but to focus on Philolaus' cosmology, the only one with a mobile earth, would seriously distort the history of early Greek cosmology. Nor is early Greek geocentrism reducible to the unreflective anthropocentrism/geocentrism of earlier cultures or the early Greek poets either. It was argued for in interesting and sophisticated ways and was thought to be supported by empirical evidence. It was only superseded, with considerable effort, by the Copernican revolution of the sixteenth and seventeenth centuries.

There were ways in which the early Greeks thought about order that are similarly neither modern nor primitive, and were plausible possibilities for

thinking about nature down to the more general scientific revolution of the seventeenth century. So I disagree with Hesse's comment that:

> In a sense the Ionians return to the primitive view in which supernatural powers are not distinguished from their revelation in nature itself.[16]

I disagree that the Ionians thought of any powers as supernatural, as there can be powers beyond inanimate matter that are entirely natural. They also clearly attempt to do something sophisticated and interesting that is beyond any simple, primitive view of the world.

An organic conception of nature was only displaced by the rise of the mechanical philosophy in the seventeenth century. A civil conception of natural law, rather than a mathematical one was common until the time of Descartes. Natural laws have only consistently been expressed in terms of equations from the time of Galileo. An interesting and important example is Plato on the heavens. Plato believed that the heavens moved in a regular and orderly manner because each of the heavenly bodies had a soul and intelligence and thus chose the best (so regular and orderly) path. Here I fundamentally disagree with Burkert, who has commented that:

> Plato thought it an inescapable conclusion that the orderly motion of the stars is due to their having souls; it is a voluntary, chosen order. Here sophisticated Greek science harks back to the pre-scientific way of thinking and comes to rest in it.[17]

As these celestial intelligences will always choose the best, and will always exist in this manner as the demiurge chooses to keep the cosmos in existence, here we in fact have an immensely strong underpinning of the regular behaviour of the heavens. It is very different from the caprice of the gods, which may or may not keep order. It is also significant for this book that while Plato looked at how an ideal intelligence can generate absolute regularity, there was no consideration in early Greek thought of how an ideal machine might generate regularity.

I take it as both meaningful and interesting to investigate this intellectual space between the modern and the primitive. Some criteria of meaning, such as verificationist or experimentalist theories of meaning would render such an investigation meaningless. I contend that we are not looking at fine distinctions between varieties of meaningless or primitive ideas, but investigating how a significant proportion of early Greek thinkers thought about order in ways that were plausible in their context and significantly different from primitive notions.

I take the content of this intellectual space to be rational ideas, which we have later come to have reason to reject. Critical for this book will be the idea of some form of cosmic intelligence that steers or controls. I hold that idea to be rational in an early Greek context, at least in that it can be coherently expressed in words, reasons for that idea can be given and coherent replies to objections made. I do not consider such an intelligence to be beyond or contrary to nature, or to use the modern term, supernatural. It is part of *phusis*, and behaves in a law-like manner, *kata phusin*, according to nature as some of the early Greeks said.[18]

Analogies

We are familiar with the phrase 'regular as clockwork' but the Greeks were not. This is important as clockwork was the key analogy for expressing the regularity of nature for the mechanical philosophy of the seventeenth century. Instead, we find the early Greeks using a variety of analogies for regularity based on contrasts. So there was civil versus rural living, ordered city versus anarchic city, ordered armies versus rabble, intelligent versus unintelligent behaviour, steered versus unsteered, controlled versus uncontrolled. That the early Greeks used political or commercial analogies to model the cosmos (e.g. Anaximander, Heraclitus) and its regularities is well known, as is the fact that Plato ascribed intelligence to the heavenly bodies and that the early Greeks used organic analogies for the structure of the cosmos. I argue that there has been an interesting reversal in expectations in relation to analogues for order. We take clockwork (or another suitable mechanism) as a paradigm for regular behaviour, and contrast that with the irregularity of humans, and have done since around the seventeenth century and the rise of the mechanical philosophy. The early Greeks though, contrasted the regularity of intelligence, particularly a pure or divine intelligence, with the irregularity of unguided processes. The early Greeks did not use 'weak analogies' as some commentators have asserted.[19] Those they used may be weak for a mechanical or modern conception of the world, but often they were good for the conceptions of nature the early Greeks actually had and gave a surprisingly strong underpinning for their views on order. Conversely, if the early Greeks had used mechanical analogues, these would have been weak, as their machines were not paradigms of regularity and order but were prone to rapid wear and breakdown. It is important here not to refer to non-mechanical analogies as 'alternative' analogies for the early Greeks. That would be to accept a historiography where mechanical analogies are always the primary analogies.

I will be interested in how the macrocosm/microcosm analogy was deployed and what was got out of this in terms of explanation and how it was thought of in terms of causation. I will be interested in the fact (again downplayed in mechanical interpretations) that some early Greek thinkers (e.g. Anaximander, the Hippocratics) believed nature to be divine. What did this help to explain? Was this a form of pantheism and could it avoid the accusation that pantheism is vacuous? I will be interested in a series of analogies used by the Greeks, biological, agricultural, human, meteorological, botanical, culinary, pyrotechnical, commercial and parenting analogies to see what work they did in their particular context.

The 'like to like' principle of the early atomists, and Love and Strife in Empedocles have both been treated as forces. One can see why commentators have pursued this view, pursuing affinities with modern science, but these were not forces. Like particles are sorted together in the vortex but not elsewhere, and there is no force acting between particles. The elements associate or dissociate in Empedocles but again no universally acting force operates between these elements. We also need to generate a history of how the like to like principle changes, from Homer where the gods lead things like to like, through the early atomists to Plato where like knows like, like causes like, and like is drawn to like.

Early Greek history

There is a benefit here in that this settles the early atomists into the mainstream of Greek thought, rather than generating a mechanist approach out of nothing, which would raise the spectre of a 'Greek Miracle'. One intention of this book is to undermine the idea of a 'Greek Miracle', by demonstrating that we have a strong context in Homer and Hesiod for ideas concerning order, which can help explain the specific examples and the language used to express them. These ideas were not generated *ex nihilo*, and while brilliant, seminal and innovative they were not miraculous. It is also the intention of this book to undermine the idea of an 'Ionian Enlightenment'. The European Enlightenment of the eighteenth century is supposed to entail the spread of mechanical and secular thought, so some see it as good if we can attribute such an Enlightenment to the Ionians as well. There was no such spread of mechanical thought in the early Greeks. Science in the European Enlightenment was done predominantly by Christians who believed they were investigating the glories of the world that their god created and maintained and there was no noticeable secularization. It is more

accurate to say that during both the European Enlightenment and the early Greek periods there was a significant and important rethinking of the relation of god/gods with nature and the investigation of nature. Finally, this book will also undermine any simple *muthos* to *logos*, myth to reason account of early Greek thought. There are important differences between Homer, Hesiod and early investigators of nature, but *muthos* to *logos* puts these changes in far too binary a form, and invites ideas of rapid and wholesale change and discontinuity that are simply not there in the evidence.

Mechanists and *mēchanē*

As I will oppose the idea that the early atomists, and indeed any early Greek thinkers were mechanists, I will say something to clarify what I mean by 'mechanists'. As Berryman comments,

> The term 'mechanical' is freely used in current scholarship in sometimes anachronistic or ill-defined – and certainly various – ways, as though it were a self-evident concept available to all.[20]

The Greek term *mēchanē* is much better translated as 'contrivance' than 'machine' for the period we are looking at. In Homer, *amēchania* signifies human helplessness in relation to the gods, while Odysseus is frequently described as *polumēchanos*, which is usually rendered resourceful but literally 'of many devices', those devices being human attributes or stratagems.[21] Aristotle also tells us that 'Anaxagoras makes use of mind as a device (*mēchanē*) in cosmos generation', whenever he is at a loss to explain (*Metaphysics* I/4, 985a8). Anaxagoras' cosmic mind can hardly be thought to be mechanical. In line with my approach to *phusis*, it is revealing to look at the negations of *mēchanē* to help determine meaning and use.

As a first differentiation, I would say there are two broad senses in which a thinker or an explanation might be thought to be mechanical. Here I follow Lonie's definitions:

> A mechanistic explanation is one which involves the mathematical application of the science of mechanics to bodies in motion.[22]

> We label 'mechanistic' an explanation which is modelled upon the workings of machines or automata.[23]

One critical point here is that one can be a materialist without being a mechanist. During the seventeenth and eighteenth centuries there was a close association of

materialism and mechanism but that has not been so for all periods. As a modern example, we have a material account of the brain. Is that though a mechanical account? We have far more sophisticated accounts and analogies for what is happening with the brain and many would deny the merit, benefit or possibility of reducing those accounts or analogies to something underlying that is mechanical.[24] Prior to the seventeenth century it was possible to be a materialist without being a mechanist. The key case for this book will clearly be the early atomists, Leucippus and Democritus, and I am happy that they have an ontology of atoms and void. The intuitive view, which has been expressed to me several times at conferences, is that Leucippus and Democritus were mechanists because of their ontology and because they explained everything in terms of the interactions of particles. I will argue though that they made no use of mathematical mechanics and they did not conceive of nature as working like a machine. Yes, they explained in terms of the interactions of particles but not the mechanical interactions of particles. It is also important not to assume that the early atomists shared some of the ideas developed by later mechanical philosophers. It is by no means clear that they share ideas about the mathematization of nature, about the vacuum or about the conservation of energy. I will also argue something stronger, which is that they could not have made use of mathematical mechanics because of their use of *ou mallon*, indifference arguments, in reply to Parmenides. Attempts to 'retrofit' a mathematical mechanics to them, which is effectively to say that a basis was there for them to have applied such mathematical mechanics, ignore this crucial context. Such attempts are also prone to attributing anachronistic assumptions to make such a mechanics work.[25] I will also argue that it is both philosophically and historically highly implausible that they would have used mechanical analogies and in fact they did not, using meteorological, maritime, biological and agricultural analogies instead as well as the macrocosm/microcosm analogy.

Unitary definition of mechanical?

It is important to recognize that there is no single 'correct' mechanical philosophy and definitions of what it is to be a mechanist vary widely.[26] Pyle gives perhaps the narrowest definition,[27] the mechanical philosophy being defined following Thomas Hobbes as the denial of action at a distance, the denial of the spontaneous initiation of motion and the denial that incorporeal agents are capable of moving bodies. The denial of action at a distance would exclude much of the mechanical

philosophy following Newton and his theory of gravity. The recently published *Routledge Handbook of Mechanisms and Mechanical Philosophy* on the other hand gives this definition of mechanism:

> A mechanism for a phenomenon consists of entities (or parts) whose activities and interactions are organized so as to be responsible for the phenomenon.[28]

The authors of this definition are aware that this is 'one by which a great number of things will count as mechanisms'. That is deliberate, as they recognize debate between many mechanistic approaches (ontological, metaphysical, methodological, epistemological) spread of many disciplines, beyond the usual mechanical physics (biology, medicine, cognitive science, neuroscience, sociology, political science, economics and history). It is notable here that neither the application of mathematical mechanics to particles nor the machine analogy are fundamental tenets of this new view that is essentially about mechanisms, which can be biological or social. There is no necessary commitment that biological or social mechanisms ought or can be reduced to material ones, or that 'entities (or parts)' such as 'people, families, political parties' can be so reduced. In terms of direction of explanation, instead of the relentless downward-looking reductionist approach, the new mechanism looks to locate mechanisms in complex situations so must look 'down, around and up'.

One thing that should be clear about this modern view of mechanisms is that if applied to the ancients, it will not cleave the early Greeks along the same lines as the teleology versus materialism or a supposed teleology versus older mechanistic view will. Indeed, Popu has argued that the arch-teleologist Aristotle makes significant use of mechanisms in this modern sense.[29] I would argue that he could be joined by several, if not all, of the early Greek thinkers beyond Leucippus and Democritus on this definition.[30] I raise these issues because it is important to challenge the linear progressive history narrative for the mechanical philosophy. It is also important to show that there have been many variations of the mechanical philosophy or mechanical or mechanistic approaches, influenced by the current state of science.[31] The nineteenth century emphasized point matter and forces, strict mechanical modelling, and avoidance of debates about the nature of matter or the issue of action at a distance in a way not seen before or since. There is no simple, atemporal, Platonic form of the mechanical philosophy. The idea of thinking about nature in a mechanistic manner is not atemporally evident, nor is it something that arises naturally in all situations. The early Greeks used analogies for natural processes that were to hand: maritime, architectural, agricultural, meteorological, craft, commercial and a host of other

analogies. They did not use machine analogies as these were not there to be used. It was only with the rise of the machine, in particular the mechanical clock and to a lesser extent more sophisticated pneumatics, that the mechanical philosophy of the seventeenth century came about.[32] We need to be careful not to project key ideas from that mechanical philosophy back onto the early Greeks, nor project back the basis that led to some of those ideas. So I radically disagree with Heidel, who has commented that for the early Greek investigation of nature:

> Even where it considered biological and intellectual processes, it started with mechanical notions and arrived in the end at materialistic conclusions.[33]

Equally I disagree that:

> When the pre-Socratic asked what a thing was, the answer he desired, if given with ideal completeness, would have presented its chemical formula.[34]

I deal with the key case of Leucippus and Democritus in Chapter 7. Other important cases of early Greeks who have had mechanistic views incorrectly attributed to them, are Anaximander (Chapter 4), Anaximenes, Empedocles and Anaxagoras (Chapter 6) and the Hippocratics (Chapter 8).

Why not or why?

I want to introduce one important historiographical nuance that will run through this book, borrowed from analyses of why a scientific revolution occurred in Europe and not elsewhere in the seventeenth century. It is possible to generate a very positive account of the history of the introduction of mechanistic ideas, and Dijksterhuis has said that:

> Among the numerous modifications that scientific thought about nature has undergone in the course of the centuries, it would be difficult to point to one that has had a more profound and far-reaching effect than the emergence of the conception of the world usually called mechanical or mechanistic.[35]

Given that the title of his book is *The Mechanization of the World Picture*, that is perhaps not surprising and is a good example of privileging mechanistic explanations. If we treat progress towards a mechanical world view as part of a linear and progressive history, the tendency is to ask where someone fits in this history, and if they do not fit, why they do not fit. Often there is an accompanying assumption that mechanical ideas are somehow natural or evident, again

prompting us to ask why someone did not fit in this history. Berryman has commented that:

> A number of classic explanations have been offered as to why ancient Greek thinkers might not have seen the applicability of ideas from mechanics to the understanding of the natural world.[36]

That is a fair assessment of how the issue has been approached. Just prior to the seventeenth century, in addition to Western Europe, both the Chinese and the Arabic/Islamic cultures had good technology and sophisticated social systems. Why then did this revolution occur only in Western Europe? If we take this scientific revolution to be a natural progression from a certain state of technological and social development, then the tendency is to ask why did it not happen elsewhere, and what other factors inhibited it. However, it is also possible to take the converse view. If this scientific revolution was not an evident, natural progression, then one might ask why did it happen in Western Europe instead. These different approaches will generate significantly different answers. This book will take the view that 'mechanization of the world picture' is not something natural or evident and will be interested in looking at questions of why anyone in early Greece would be attracted to it, especially in the absence of machines or a developed science of mechanics. Whether we phrase the question as 'why?' or 'why not?' will be applicable to several other issues this book will address.

Modern and seventeenth-century mechanical philosophy?

As someone who teaches some aspects of History and Philosophy of Science from the ancients through to the moderns, it has always puzzled me that debates about mechanistic thought in the ancient world use the mechanical philosophy of the seventeenth century as a reference point. There have been significant developments both in the nature of the mechanical philosophy and its status since then. This can be masked by linear progressive histories of mechanization, especially if those histories stop soon after the seventeenth century, as Dijksterhuis' does. So too referring to the science of the seventeenth century as 'early modern science' (in contrast to the ancient/medieval science that it allegedly abruptly replaced) can also give the sense that the fundamentals of modern science are in place with the mechanization and mathematization of the seventeenth century, so there is continuity with modern science. This is not so.

The mechanical philosophy in its classical form of particles interacting by contact action only failed to account for gravity.[37] Gravity after Newton was thought of as a force acting at a distance, not reducible to the collisions of atoms as in Descartes' vortex theory of gravity. One can reformulate a new mechanical philosophy to include such forces, but it is a significant change. General Relativity treats gravity in an entirely different manner, which cannot be thought of as mechanical in any meaningful sense.

Mechanical chemistry failed. Treating chemistry as the interactions of the philosophically smallest particles proved unproductive. Only when Lavoisier defined a chemical element as something that could not be broken down further *by chemical means* did chemistry arrive at a useful theoretical foundation. Mechanical biology failed, quite spectacularly. The use of the new microscopes in the eighteenth century generated many novel discoveries in morphology, embryology, reproduction and cytology, which the mechanical philosophy of the time was unable to cope with in any plausible manner.[38]

The rise of quantum mechanics has also been problematic for the mechanical philosophy. One key issue is that it is clear that the micro, quantum world does not behave like the macro world, so any analogy from the macro world, let alone a machine analogy, is likely to be inappropriate. Sub-atomic particles simply do not behave like miniature snooker or pool balls. Quantum indeterminacy, quantum tunnelling, wave/particle duality, and a fundamentally probabilistic interpretation of nature all run counter to the mechanical philosophy. One might argue that although the initial mechanical chemistry failed, the later solid atom or the electron/proton/neutron atom with solid sub-atomic particles reinstated a mechanical view. However, modern chemistry has long passed beyond this simple model and is underpinned by quantum mechanics, which gives such a good account of electron orbits, energies and bonding characteristics that chemistry is in one sense considered theoretically closed. I agree with Garber and Roux that:

> However mechanical philosophy is defined, its ambition was greater than its real successes.[39]

Newtonian science is still taught to a certain level on science courses as it is a reasonable description of slow-moving macro objects and is a good way of introducing many scientific ideas, but for proper science it has long been superseded. So too the idea of the mechanical modelling of phenomena in terms of 'levers, springs, pulleys, wheels, gears, deformable jelly, etc.'[40] or the favourite seventeenth- and eighteenth-century analogy of clockwork has long been superseded in favour of more sophisticated, flexible, layered and interactive ways

of understanding phenomena. The *Routledge Handbook of Mechanisms and Mechanical Philosophy* comments that:

> Although mechanical philosophy receded for much of the twentieth century, it is again resurgent.[41]

One can see why the first part of this comment is true from the development of scientific ideas in the twentieth century. It is also true that mechanical explanations are having something of a revival, but in a very different form. As we saw above, the new conception is that 'mechanism for a phenomenon consists of entities (or parts) whose activities and interactions are organized so as to be responsible for the phenomenon' and that is a much broader conception of what constitutes a mechanical explanation,[42] which would have been rejected out of hand by seventeenth-century mechanical philosophers.

Nature and *phusis*

The standard Greek term for nature was *phusis*. It can mean the nature of something, whether that is of an object or a person, and can also mean nature in the broader sense as one might talk of the nature of the universe. Aristotle gives several definitions of *phusis* in *Metaphysics* V/4. The term *phusis* also has connotations that are not fully captured by the translation 'nature'. First, it has a sense of giving the origins, development and current constitution of something, as LSJ have it '*origin . . . the natural form* or *constitution* of a person or thing *as the result of growth*.' Second, *phusis* derives from *phuein*, 'to grow', and so can carry a strong organic sense to it. Third, as Mourelatos has recently argued, the verb *phuein* can have a sense of dynamic being, of coming into being, where the verb *einai* (to be) expresses a more static sense of being.[43]

The first use of *phusis* is in Homer, where Hermes shows Odysseus the *phusis* of the Moly plant. It is common here to undermine this use of *phusis* by saying that the Moly is magical.[44] I disagree, for a reason outlined above. Homer had no conception of or term for nature or anything contrary to nature in the broader sense, so had no conception of, or indeed term for, magic. He may have ascribed more powers to plants than we would, but could not and did not distinguish between magical and non-magical plants. No doubt we, from a modern perspective, consider the Moly to be magical, but that is not the point – Homer did not. This is though the only use of *phusis* in Homer or Hesiod and did not give a general notion of *phusis*.[45]

On the issue of whether the early Greeks invented a conception of nature or not, I hold a position between that of Grant,[46] who argues it was not, but was a given for all humans, and Lloyd who argues it was invented.[47] I hold that the Greeks discovered the idea of a domain of nature that can be contrasted to a domain of non-nature, which does not exist, but had to generate the contents of that domain.[48] Some of that generation was discovery, some invention.

Plato and *peri phuseōs historia*

At Plato's *Phaedo* 96a8, we find the phrase *peri phuseōs historia*, 'enquiry concerning nature'. It is important that we are clear about the meaning of this phrase, especially as it has been used for some early Greek thought. The term *historia* is relatively unproblematic, though I prefer 'enquiry' to 'investigation' as it gives a looser, less methodologically rigid and more philosophical sense to the project, which I believe to be appropriate.[49] The real issue is with the Greek term *phusis* and more generally with the cognate terms *phusikoi* and *phusiologoi*, literally 'naturalists' and 'those who talk about nature'. It is highly misleading here to translate *phusis* as 'physics' or something similar, or to translate *phusikoi* or *phusiologoi* as 'physicists'.

The early Greek enquiry into nature was much broader than any modern conception of physics. This is clear from any inspection of what is included in works titled '*Peri Phuseōs*'. It is also clear that Plato recognized this, from *Phaedo* 96a5, where the questions Socrates first mentions in relation to *peri phuseōs historia* are to do with coming to be, existing and perishing, zoogony, psychology, epistemology and cosmology. So too in the *Timaeus* where Plato gives an account of *phusis*, giving the origins, development and current constitution of the cosmos and living things. The cosmos itself is a living thing and there is of course great emphasis on coming into being. This may seem relatively evident, but it is alarming how often terms such as physics, physicist and materialist are used in this context even in relatively modern work.[50] Physics/physicist also has connotations of physicalism or materialism, which are inappropriate for many thinkers before Plato. Only Leucippus and Democritus qualify as physicalists or materialists. Anaxagoras and *nous* would be a key example here, not least because Plato recognized Anaxagoras and *nous* as part of this enquiry concerning nature. We also need to be careful about the phrase 'physical explanation'. If what is meant by this is that some early Greek thinkers explained in terms of *phusis*, rather than in terms of the gods,[51] then that is

generally, though not exclusively, true.[52] If what is meant is that explanation was in terms solely of physical entities, then that is quite false. A better phrase would be natural explanation. Grant has defined natural philosophy as 'all enquiries about the physical world', where I would insist on 'all enquiries about the natural world', especially for the early Greeks who believed there to be natural non-physical entities.[53] It is of course important to bring our understanding of *peri phuseōs historia* into line with modern discussions of the full connotations of meaning of *phusis*.

Plato and *peri phuseōs skopein*

Plato did not reject all of *peri phuseōs historia* either in the *Phaedo* or elsewhere, or consider *peri phuseōs historia* to be entirely physical or mechanical in ontology or explanation.[54] In the *Phaedo*, he accepted an explanation of the earth's stability in terms of equipoise and also accepted a like to like principle. In the *Philebus* Plato says that:

> Well, Protarchus, should we say that the whole universe is ruled by unreason, irregularity and chance, or on the contrary, as some of those who came before us said, say that *nous* and a marvellous organizing intelligence steer (*diakubernan*) it.[55]

So Plato recognized and approved of a tradition of thinking in terms of *kubernan* in his predecessors.[56] Another significant passage is *Gorgias* 508a1–5:

> The wise (*hoi sophoi*) said this, Callicles, that heavens and earth and gods and humans hold together by partnership, friendship, propriety, self-control and justice. This is why they call this whole a cosmos, O friend, and not disorder or intemperance.

Again, Plato recognized a tradition of explanation in cosmology that went beyond the physical or mechanical. One reason for the overestimation of the extent to which early Greek thinkers were mechanists stems from a too stereotypical approach to Socrates' autobiography whereby Plato is supposed to reject all of *peri phuseōs historia* as physical or mechanical. I also reject the idea that Plato had only one typology or taxonomy for earlier natural philosophy.[57] So, for example, the 'gods and giants' distinction of the *Sophist* is different from that employed in Socrates' autobiography in the *Phaedo*, as is the contrast between those who believed in an 'indefinite plurality of things' and those who

did not,[58] those who employ *tuchē* (chance) and those who do not or those who employed *ou mallon* arguments and those who do not. Plato did not have a simple teleology versus physical/mechanical views bifurcation for earlier natural philosophy.[59]

This is important as it gives us more flexibility in understanding earlier natural philosophy and gives us some further insights into some debates. It is also important evidence that it would be wrong to see early Greek thought simply as telelologists versus mechanists, or even teleologists versus materialists. In conjunction with the proliferation of uses of *kubernan* and *kratein* listed above, these passages from the *Philebus* and the *Gorgias* give us justification for the investigation of other possibilities.

It is also critical to recognize that Socrates' biography is not the only source of information in Plato on the *peri phuseōs* tradition. At *Phaedrus* 270cd, Plato has Socrates say:

> So see what Hippocrates and true reason (*ho alēthēs logos*) say concerning nature (*peri phuseōs skopei*).

This passage is interesting for Plato scholarship, as Plato clearly thinks that there is a proper method for conducting some form of enquiry *peri phuseōs*,[60] and this is at least part of it.[61] This discussion of method is prompted by Socrates' question of whether it is possible to gain any worthwhile knowledge of the nature of the soul (*psuchēs oun phusin*, 270c1) without the nature of the whole man (*tēs tou holou phuseōs,* 270c2). Phaedrus replies that if Hippocrates is to be trusted, we cannot know the body either except by this means of pursuing the enquiry (*Phaedrus* 270c).[62] It is also worth noting here that Plato and Hippocrates had a dynamic conception of *phusis*, as at *Phaedrus* 270d we ought to investigate its power to act (*skopein tēn dunamin autou*).

With the multiple uses of *skopein* in this passage, we could just as easily use *peri phuseōs skopein* as we could *peri phuseōs historia.* Here *skopein* means to contemplate/consider/examine/observe, so perhaps the simplest English translation would be 'the contemplation of nature'.[63] It is important that we do not fixate on Socrates' autobiography as the supposed primary source of information on Plato and early Greek thought, and it is also important that we do not have too stereotypical an account of Socrates' autobiography. There are of course agendas in play here in relation to Plato, so I will make my own clear. I take Plato to be serious and sophisticated in discussing his own natural philosophy and also sophisticated in discussing or alluding to earlier Greek thought on nature.

Conclusion

This book then will argue for the importance of a tradition of *kubernan* and *kratein* as key ideas in early Greek thought on nature and will argue that no early Greek was a mechanist in any meaningful sense. I emphasize again that this is not to deride or downgrade the early Greeks who had interesting ideas on how the cosmos gained and maintained order. It does though raise questions of what we value and why in their thought. Some, especially those who are sceptical or opposed to this line of thought, might like to read the chapter on Leucippus and Democritus first, as these are the best candidates for mechanists in early Greek thought. I will proceed chronologically though, as I think there is much to be gained from a fresh and more flexible look at Homer and Hesiod on issues of order and how the Ionian thinkers may have been influenced by and transformed their ideas.