Space

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A HISTORY

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OXFORD PHILOSOPHICAL CONCEPTS

Edited by ANDREW JANIAK

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Christia Mercer, Columbia University

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Oxford University Press is a department of the University of Oxford. It furthers the University's objective of excellence in research, scholarship, and education by publishing worldwide. Oxford is a registered trade mark of Oxford University Press in the UK and certain other countries.

Published in the United States of America by Oxford University Press
198 Madison Avenue, New York, NY 10016, United States of America.

CIP data is on file at the Library of Congress
ISBN 978–0–19–991412–8 (pbk.)
ISBN 978–0–19–991410–4 (hbk.)

1 3 5 7 9 8 6 4 2

Paperback printed by Marquis, Canada
Hardback printed by Bridgeport National Bindery, Inc., United States of America

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Series Editor's Foreword

Oxford Philosophical Concepts (OPC) offers an innovative approach to philosophy's past and its relation to other disciplines. As a series, it is unique in exploring the transformations of central philosophical concepts from their ancient sources to their modern use.

OPC has several goals: to make it easier for historians to contextualize key concepts in the history of philosophy, to render that history accessible to a wide audience, and to enliven contemporary discussions by displaying the rich and varied sources of philosophical concepts still in use today. The means to these goals are simple enough: eminent scholars come together to rethink a central concept in philosophy's past. The point of this rethinking is not to offer a broad overview but to identify problems the concept was originally supposed to solve and investigate how approaches to them shifted over time, sometimes radically.

Recent scholarship has made evident the benefits of reexamining the standard narratives about western philosophy. OPC's editors look beyond the canon and explore their concepts over a wide philosophical landscape. Each volume traces a notion from its inception as a solution to specific problems through its historical transformations to its modern use, all the while acknowledging its historical context. Each OPC volume is a history of its concept in that it tells a story about changing solutions to its well-defined problem. Many editors have found it appropriate to include long-ignored writings drawn from the Islamic and Jewish traditions and the philosophical contributions of women. Volumes also explore ideas drawn from Buddhist, Chinese, Indian, and other philosophical cultures when doing so adds an especially helpful new perspective. By combining scholarly innovation with focused and astute analysis, OPC encourages a deeper understanding of our philosophical past and present.

One of the most innovative features of Oxford Philosophical Concepts is its recognition that philosophy bears a rich relation to art, music, literature, religion, science, and other cultural practices. The series speaks to the need for informed interdisciplinary exchanges. Its editors assume that the most difficult and profound philosophical ideas can be made comprehensible to a large audience and that materials not strictly philosophical often bear a significant relevance to philosophy. To this end, each OPC volume includes Reflections. These are short stand-alone essays written by specialists in art, music, literature, theology, science, or cultural studies that reflect on the concept from their own disciplinary perspectives. The goal of these essays is to enliven, enrich, and exemplify the volume's concept and reconsider the boundary between philosophical and extraphilosophical materials. OPC's Reflections display the benefits of using philosophical concepts and distinctions in areas that are not strictly philosophical and encourage philosophers to move beyond the borders of their discipline as presently conceived.

The volumes of OPC arrive at an auspicious moment. Many philosophers are keen to invigorate the discipline. OPC aims to provoke philosophical imaginations by uncovering the brilliant twists and unforeseen turns of philosophy's past.

Christia Mercer
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Abbreviations and References

Ancient Works

DK = *Fragmente der Vorsokratiker*. Edited by H. Diels and W. Kranz. Berlin, 1951.

Aristotle

References to works by Aristotle use so-called Bekker numbers, which correspond to the pagination and line numbers of Bekker's 1830 edition of the text. These will be found in the margins of any reliable edition or translation.

Descartes

AT = *Oeuvres de Descartes*. Edited by Charles Adam and Paul Tannery. Paris: Vrin, 1996.

H = *Treatise of Man*. Edited and translated by Thomas Steele Hall. Cambrdige, MA: Harvard University Press, 1972. The title of this work is more usually translated as *Treatise on Man*, and that form is used herein.

O = *Discourse on Method, Optics, Geometry and Meteorology.* Translated by Paul J. Olscamp. New York: Bobbs-Merrill, 1965. The title of Descartes's *Dioptrique* is translated herein as *Dioptrics* (as opposed to *Optics*).

Kant

A/B: A = corresponds to the first-edition pagination of Kant, *Critique of Pure Reason* (1781); B = corresponds to the second-edition pagination of the *Critique* (1787).

References to all other texts in Kant's corpus are to the volume and page numbers in the Akademie edition, *Kants gesammelte Schriften* (Berlin, 1902–).

Plato

References to works by Plato use so-called Stephanus numbers, which correspond to the pagination and line numbers of a famous Renaissance edition of Plato's texts that appeared in the late sixteenth century. That edition used the letters a–e to split up sections of the text. Any reliable edition or translation will include these numbers in the margins.

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Introduction

Andrew Janiak

Space is ubiquitous. So are spatial concepts. Scholars in architecture, art history, mathematics, cosmology, ecology, neuroscience, sculpture, chemistry, and geography employ concepts of space and articulate concepts with spatial components. It would be hopeless to list them all, and equally fruitless to search for patterns among them, or for their common node. One needs a specific focal point. In our case, the history of philosophy—and the ways in which philosophers in different eras have pondered space—is our focus. We will also consider some of the myriad intersections between philosophical discussions of space and treatments in other disciplines and enterprises. Some of these intersections are obvious: philosophers and scientists in the nineteenth century were deeply influenced by and played important roles in articulating the new non-Euclidean geometry developed by mathematicians like Bolyai and Lobachevsky. The intertwining of

Andrew Janiak, *Introduction* In: *Space.* Edited by: Andrew Janiak, Oxford University Press (2020).

DOI: 10.1093/oso/9780199914104.003.0001

the history of geometry with the history of philosophical treatments of space is intimate and obvious. Other intersections are less obvious: Were early modern philosophers influenced by the development of Renaissance perspective? How did the emergence of microscopy affect philosophical conceptions of space? We will emphasize some of these connections through the essays on philosophers' views in various eras and through our short essays, or "Reflections," interspersed throughout the volume.

Since our volume is organized historically, our first task is to avoid a harmfully anachronistic presupposition in approaching space. We do not presuppose that each era broached in this book—from early antiquity to modernity—involved philosophers who thought about what *we* now call *space*. Nor do we assume that there is a *single* concept of space whose history we can trace. There may very well be concepts with an unambiguous history that can be traced through time, but SPACE is not one of them.[1] Instead, we have jointly adopted several guiding questions, including the following: Did philosophers in previous eras think about something called space? Did they have a concept of space at all? Or were they primarily thinking about concepts with spatial significance, such as the concept of an object, a person, a city, or a place? Just as important, did they regard space as a significant topic of philosophical reflection, analysis, and debate? If they did, was that due to reasons internal to philosophy or ones arising from theology, mathematics, natural science, or elsewhere? In this sense, although our official title is *Space: A History*, we might also embrace the alternative, *Space: The Emergence of a Concept.* Unsurprisingly, it took centuries for our modern SPACE to emerge, or perhaps for a single concept to emerge. Tracing that emergence is our joint task in this volume.

Another potential anachronism, and attendant confusion, arises from the insistence on a historical perspective for philosophy, coupled

1 Following convention, the concept is hereafter denoted SPACE, thereby distinguishing it from both space itself and the word "space."

with the failure to apply the same wise rule to other disciplines. For instance, we may insist that philosophers in the first half of the seventeenth century treated space differently from those in the second half, and then forget to treat accompanying developments in, say, experimental technology with the same historical care. Perhaps for obvious reasons, it is especially important for our approach to recognize historically shifting conceptions of geometry during the epochs under study in this volume. To a contemporary reader, geometry is important in this context because it just is the science of space. Concomitantly, it may seem obvious that the approach outlined in Euclid's *Elements* was the first systematic attempt to understand the nature of space. But in earlier historical periods, philosophers and mathematicians did not necessarily regard Euclid as providing a doctrine or treatment of something called space or as a description of what we would call physical space (as Jeremy Gray discusses in his Reflection). That may sound odd to modern ears, but caution in this area seems to be warranted by the ancient and medieval evidence. Indeed, some influential scholarship suggests that in previous periods in history, Euclid was sometimes regarded as discussing not space (or SPACE) but the construction of figures and their various properties. A fully historical approach, then, will provide not only a historically precise conception of philosophy but an equally precise, historically rich conception of the various disciplines with which philosophers engaged in dialogue throughout the ages.

The Oxford Philosophical Concepts series includes a novel element mentioned earlier: it enriches the chapters written on different eras in philosophical history with short essays called "Reflections" that tackle related developments in myriad other fields. The Reflections in this volume fall into two broad categories. First, some of them are easily paired with closely related philosophical essays. Because Gary Hatfield's chapter concerns philosophical theories of vision and optics from the Middle Ages to modernity, it is nicely paired both with Mari Hara's essay on the use of perspective in Renaissance painting and with

Jennifer Groh's contribution on the understanding of visual space in contemporary neuroscience. The art historian Hara documents the ways in which Italian Renaissance artists famously and influentially employed their knowledge of geometry and optics to introduce linear perspective into their painting and architecture, thereby bridging the expected gap between art and science. Groh's essay, written from the perspective of a neuroscientist, shows the ways in which populations of neurons form a map that mirrors the perceived topography of some region in the world. The historian of science Mi Gyung Kim's Reflection on early modern laboratory spaces, which discusses figures such as Boyle and Newton, is easily paired with Andrew Janiak's chapter on early modern conceptions of space. Kim shows that the early modern chemical laboratory contained equipment—such as Boyle's air pump—designed to operationalize the notion of empty space, but also served to represent an ideal social order. In another case, two Reflections intersect nicely with one another. Jeremy Gray concisely characterizes the fascinating and complex story of how mathematicians came to regard Euclidean geometry as merely one among a set of possible geometries, some of which involved a different notion of lines than is contained in the famous parallel postulate. The veritable explosion of philosophical ideas that accompanied this story—from the development of conventionalism to the rethinking of a priori knowledge—is well known. The Reflection by the mathematical sculptor George Hart brings Gray's discussion into dialogue with contemporary artistry by showing how one can sculpt objects to express intriguing features both of Euclidean and of non-Euclidean spaces. The remarkable images of Hart's sculptures in this volume will assist readers in imagining a wide array of spaces.

The Reflections in the second broad category are not paired one-to-one with our philosophical chapters or with other Reflections. They approach space from the perspective of other disciplines—especially cultural geography and ecology—that raise intriguing questions, ones that philosophers may have overlooked. These Reflections help to enrich our overall treatment of space and its concepts over the centuries. The Reflection by the cultural geographer Banu Gökariksel discusses public spaces in Istanbul from a sociopolitical perspective, indicating (e.g.) that a particular place within a global city can be gendered in various ways that are rendered legible primarily through detailed scholarship on the group. Philosophers and mathematicians have often noted that a space might be *occupied* or *empty, curved* or *flat*; it expands their imaginations to show how a space might be *gendered*. The Reflection by the biologist Nicole Heller, which concerns the methods used in ecology to infer evolutionary facts from the patterns of organisms in space, serves to challenge philosophical assumptions about what counts as an object or a body occupying space. When the object in question is an ant colony—it is the entity falling under selection pressure rather than the individual organism—we encounter intriguing questions about the sense in which it behaves both like a single object occupying some large space and like a series of autonomous entities, each moving through space independently of the others. Clearly, ant colonies pose tough questions for the metaphysically minded.

When we jointly conceived of this volume's contents, it was initially tempting to include only Reflections that would pair neatly with our philosophical essays. But we resisted the temptation. Just as the first set of Reflections may enrich the way in which philosophers think about their own history, the second set of Reflections may prod philosophers to think about space from a novel perspective. After all, philosophers may not ordinarily think that a space can be gendered and that a location can help to constitute one's gender identity. So we include these disciplinarily varied and highly creative Reflections to avoid the attractive, but ultimately unwise, plan of neatly matching the contents of each chapter with a specific and clearly related Reflection. It might make sense to approach certain concepts, especially concepts that are primarily or solely philosophical in character, in that way—one thinks of consequentialism or idealism—but philosophers do not hold exclusive, or even primary, sway over the concept of space. They never have.

Indeed, philosophers have thought about space in considerable depth over the centuries, but so have architects and geographers, biologists and geometers, artists and physicists. Our Reflections do not *comprehensively* represent these various disciplinary approaches to space, which may be an impossible task, but they do provide an entrée into a wider world, enriching the set of possible ideas about space a philosopher might have in her scholarly repertoire.

Even a causal reader will notice that our treatment of SPACE ends in the high Enlightenment with the work of Immanuel Kant. We have chosen not to bring the discussion up to the present. This choice is not intended to signify that philosophers and their compatriots simply stopped thinking about space after Kant. In a way, it is meant to signify, or to admit, something like the very opposite! Space became more important after Kant, not less. First of all, as is evident already in the "Transcendental Aesthetic," the first main section of the *Critique of Pure Reason* (first edition, 1781), Kant placed the discussion of space at the very heart of his philosophical revolution. His treatment of the representation of space—contending that it is a pure intuition rather than an empirical representation of any kind, or a concept (*Begriff*) of any kind—is already understood to undergird transcendental idealism in some significant ways. Second, this emphasis on space and its representation was prescient: philosophical developments (following Kant's work) conspired with parallel developments in natural science and mathematics to ensure that space would remain a major topic of consideration throughout the nineteenth and twentieth centuries. As Gray chronicles in his Reflection, the nineteenth century saw the rise of non-Euclidean geometry, a revolutionary development involving the work of Bolyai, Lobachevsky, and Gauss. This striking change in mathematics was perhaps overshadowed by the even more impressive beginning of the new century: by 1905 Einstein's first revolutionary ideas, contained in the *special* theory of relativity, taught the world to speak of "space-time" rather than space and time separately. A mere decade later, Einstein's second burst of revolutionary ideas, expressed in his *general* theory, meant that space would forever be thought of as exhibiting non-Euclidean features (such as variable curvature) based on the distribution of mass-energy. These developments were not merely revolutionary in the sense that they overturned centuries of assumptions in mathematics, philosophy, and science—they went so far as to trespass the bounds of what had been assumed to be possible at all. It's shocking enough to hear that Euclid did not have the final word on geometry after roughly two thousand years; it's another thing entirely to learn that the real world is non-Euclidean and that space itself interacts causally with material objects on a vast, cosmological scale. These are ideas that Isaac Newton would not have dreamed of on his wildest day.

Given all the excitement concerning space in the nineteenth and twentieth centuries, the reader may wonder why this volume ends just before these developments took shape. Intriguingly, these developments are not merely exciting per se; they are intimately connected—one might say, internally related—to the development of analytic philosophy itself. As is well known, analytic philosophy emerged in the early twentieth century in part through the influence of logical positivism on the pragmatism-infused thought of Americans like W. V. O. Quine and many others. And for its part, logical positivism was centrally concerned with the revolutionary developments in mathematics and science during its own heyday, developments in which SPACE played a leading role. It is no coincidence, for instance, that Moritz Schlick, a founding member of the Vienna Circle, published one of the very first books concerned with the general theory of relativity (in 1917), with Hans Reichenbach publishing a distinctive treatment of relativity just three years later.[2] Similarly, Rudolf Carnap's most important early

2 Moritz Schlick's *Raum und Zeit in der gegenwärtigen Physik* (Springer, 1917) went into several editions; by 1920 it was already on its third edition and was translated into English that same year by Henry Brose of Christ Church, Oxford, as *Space and Time in Contemporary Physics* (reprinted by Dover in 1963). Schlick's account was certainly tracking "contemporary physics": the edition of 1920 had to be changed to reflect the remarkable confirmation of Einstein's general theory of relativity the year before! See also Hans Reichenbach, *Relativitätstheorie und Erkenntnis apriori*

publication, which involved the intersection of philosophy, physics, and mathematics, was entitled *Der Raum* (Space) and appeared just a few years after Schlick's work.[3] By the end of the 1920s, Reichenbach had already contributed another major work on space and time.[4] Since the discussion of space and time was central to science and mathematics during the Vienna Circle, they were central to the newly emerging philosophy of that time. In tandem, since philosophy of science was central to the development of analytic philosophy in the English-speaking world in the previous century, and space and time, in turn, have always been central topics within philosophy of science, the literature within analytic philosophy on space and time is vast.[5]

These facts about the twentieth century mean that recent developments concerning space have received the lion's share of the attention in the past few decades. The interested reader will have no trouble finding philosophical accounts of space and time from just about any moment in the past century or more. However, scholarly treatments of space and of SPACE in antiquity, the medieval period, the Renaissance, and the early modern period are much less common. In this way, our volume can serve as a kind of supplement to the existing

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(Berlin: Springer, 1920), which was translated by Maria Reichenbach in 1960 as *The Theory of Relativity and a priori Knowledge* (Berkeley: University of California Press).

3 Rudolf Carnap, *Der Raum: Ein Beitrag zur Wissenschaftslehre*, Kant-Studien Ergänzungshefte 56 (Berlin: Reuther and Reichard, 1922).

4 Hans Reichenbach, *Philosophie der Raum-Zeit-Lehre* (Berlin: De Gruyter, 1928), translated in 1957 by Maria Reichenbach and J. Freund as *The Philosophy of Space and Time* (New York: Dover).

5 In addition to the translations of important publications by members of the Vienna Circle (see, e.g., notes 2 and 4 above), major works in English-speaking philosophy dealing with space and time published over the past fifty years include the following: Adolf Grünbaum, *Philosophical Problems of Space and Time* (New York: Knopf, 1963); Howard Stein, "Newtonian Space-time," *Texas Quarterly* 10 (1967): 174–200; Bas van Fraassen, *An Introduction to the Philosophy of Time and Space* (New York: Random House, 1970); Larry Sklar, *Space, Time and Spacetime* (Berkeley: University of California Press, 1974); Jill Van Buroker, *Space and Incongruence* (Dordrecht: Reidel, 1981); Michael Friedman, *Foundations of Space-time Theories* (Princeton, NJ: Princeton University Press, 1983); John Earman, *World Enough and Spacetime* (Cambridge, MA: MIT Press, 1989); Robert DiSalle, *Understanding Spacetime* (Cambridge, UK: Cambridge University Press, 2006). The literature is simply too vast to do it justice here.

philosophical scholarship.[6] The monumental importance of the twentieth century for thinking about space cannot be denied. But perhaps we can supplement our knowledge of that time by producing a volume in which we give pride of place to figures whose ideas about space are less well known. Hence in this volume, in lieu of discussing Riemann and Einstein, Poincaré and Minkowski, we emphasize the likes of Aristotle and Proclus, Hobbes and Kant, Ibn al-Haytham and Leibniz.

One happy consequence of our approach is that our volume exhibits a kind of intellectual unity. For all of the figures in this volume, geometry was Euclidean, space and time were separate things, and both geometrical space and the physical space in which we live could be fundamentally understood through the kinds of reasoning already codified in antiquity. Naturally, the figures discussed in this volume engaged in vociferous disputes on a wide range of topics: the finitude of the world, space's basic relation to matter, the possibility of the vacuum, God's relation to space and the world, and so on. But all of these disputes occurred within certain basic intellectual confines. Obviously, Euclid and Aristotle lived in a fundamentally different world than Kant, but in this respect their intellectual horizons were remarkably and profoundly aligned. For this reason, the Reflections by Gray and Hart, which concern the emergence of non-Euclidean geometry in history and the possibility of its representation through mathematically sophisticated sculpture, serve to form a kind of intellectual boundary for our volume. Since they discuss the developments in mathematics that would help to usher in a new world, the world that we now occupy,

6 Even the very best works, ones with the most sophisticated historical accounts of the development of physics and concomitant ideas about space and time, will tend to give pride of place to the nineteenth and twentieth centuries, even while acknowledging the significance of earlier ideas and figures. Although they occupy decidedly distinct philosophical perspectives, Cushing and Torretti both illustrate this broad point in their works from the very late twentieth century. See James Cushing, *Philosophical Concepts in Physics* (Cambridge, UK: Cambridge University Press, 1998), and Roberto Torretti, *The Philosophy of Physics* (Cambridge, UK: Cambridge University Press, 1999), both of which begin with antiquity (Aristotle, Ptolemy, etc.) but move quickly on to Newton and then beyond.

they are profoundly important. But from the perspective of the historical figures that appear throughout our volume, these developments were not far off on the horizon—they were beyond the horizon. Lying beyond the limits of what was considered possible, they occupied an intellectual space exceeding the limits of the human imagination. This volume tries to capture a bit of what it was like to live in that world, which is now long passed.

CHAPTER ONE

Space in Ancient Times

FROM THE BEGINNING TO ARISTOTLE

Barbara Sattler

1. Introduction

In the roughly four hundred years from the earliest Greek texts to Aristotle, many of the most basic questions about space were raised for the first time in western thought and answered in a great variety of ways. These are questions such as What is the task of space—is it to answer the question where some body is situated and where it is moving, or is it rather to delimit one thing from another and thus to be a condition for plurality? Does it have an internal structure? If so, what is its internal structure like? Is space itself some kind of a bodily entity, or is it nonbodily, as, for example, a vacuum? And what do the answers to these questions tell us about its ontological status? Is it of the same status as the bodily things? Is it something more fundamental, given that everything seems to need to be somewhere in order to exist? Or

Barbara Sattler, *Space in Ancient Times* In: *Space*. Edited by: Andrew Janiak, Oxford University Press (2020). © Oxford University Press.
DOI: 10.1093/oso/9780199914104.003.0002

is it just a feature of bodily things and as such ontologically dependent on bodies?

While most of these questions will at least be touched upon, I will concentrate here on one important stream in the development of spatial thinking during the early ancient period: the establishment of space as a magnitude independent of time that can nevertheless be combined with time. If we look at prephilosophical or the earliest philosophical accounts of space, for example, at Hesiod's and Anaximander's, we see that time and space (and sometimes also matter) are often not clearly distinguished: something is described as far off, where this might be meant either temporally or spatially or both. And Anaximander's *apeiron* seems to be the basic ground out of which everything develops, materially, temporally, as well as spatially. This lack of a clear distinction between time and space leads to problems when we try to give an account of motion, as motion requires an understanding of the relationship between time and space. With the atomists Leucippus and Democritus we will see a first attempt to develop a clear notion of space in contrast to matter. But the atomists are completely silent on the notion of time. And simply omitting one of the two magnitudes, time or space, when accounting for motion leads to another kind of problem, as Zeno's paradoxes will show.

The next steps in this development can be seen with Plato's *Timaeus*: drawing on atomistic as well as Pythagorean ideas concerning space, it posits time and space as two completely independent magnitudes. Time is created and introduced in order to make the universe more intelligible, while space—Plato's receptacle, which some scholars have also understood as exhibiting features of matter—is uncreated and an essential part of what Plato's "creator" god starts out with and has to put into order. In fact, time and space are so different that it is unclear how they could be combined at all for the purposes of giving an account of motion.

This task, central for any natural philosophy, is finally tackled in Aristotle's *Physics*. Aristotle's conception of *topos* as the first immobile limit of an object's surrounding is often understood as a mere notion of a vessel. As such it seems not only to be too narrow to be of any use for understanding motion but also to be merely an account of place, not of space. I will show, however, that Aristotle in fact provides us with an understanding of *topos* that prepares the notion of a general frame of reference, which allows for locating things in the world as well as for an account of motion. What enables Aristotle to combine space with time in his account of motion and to reply to Zeno's paradoxes of motion is his understanding of both time and space as continua.

But before we jump into the unfolding of this story, let us start with a few general methodological considerations.

1.1. Methodological Prelude: Problems and Possible Criteria for Space

The period dealt with in this chapter raises at least two serious problems for an investigation of space:

1. Several of the thinkers we will consider do not have an explicit account, notion, or concept of space; explicit discussion of how to understand space only starts with Plato and Aristotle. I hope to show that it is nevertheless fruitful to look at the way pre-Platonic thinkers deal with what we consider to be spatial ideas or notions. But in order to understand how far implicit accounts of space can be found in these thinkers, we ourselves will have to think about possible criteria for space that allow us to identify such spatial notions.
2. Some of the most important spatial terms in Greek in this period—*chôra, topos, diastêma*, and *kenon*—do not necessarily match one to one with our spatial vocabulary.

Let us look at both points in somewhat more detail.

1.1.1. POSSIBLE CRITERIA FOR SPACE

What we understand by space depends, among other things, on how it is related to bodies: Is it itself a body like other physical bodies in the world (presumably just somewhat bigger), as, for example, a container? Or is it genuinely different from ordinary bodies? If the latter, is space just the relation of bodies or its own entity?

Furthermore, we will have to look at the question of whether it has an internal structure and, if so, whether it is orientable, bounded, or infinite, or its opposite. Is it everywhere homogeneous or not, isotropic or anisotropic, continuous or discrete?[1] Does space possess a particular dimension? Is it metrizable?[2] And what are the consequences of assuming space to have a certain structure? For example, if we assume our space to be finite and bounded, it seems that a linear motion will have to stop at a certain point.

The most important point for an understanding of space, however, seems to be the question of what we take its function to be: Is space that in which something can be situated, that in and through which something can move, or that which separates or delimits one thing from another? What we take the main task of space to be will also depend on whether we think of it as physical or mathematical space. As physical space, it should explain at least one decisive aspect of the objects of our experience: either the possibility of their motions or their separateness or (at least in part) their shape. As a mathematical space, on the other hand, one of its main virtues should be that it allows for all possible mathematical constructions in such a way that for whatever construction we perform, we will never run out of space.

However, while *we* take the distinction between mathematical and physical space to be vital, we will have to investigate whether it is at all

1 By "isotropy" we normally understand that something exhibits equal properties in all directions, while "homogeneity" means that something is uniform throughout.

2 Some of these features we are more used to from mathematical spaces (e.g., orientability), some from physical ones.

important for the ancients. At least within the Pythagorean tradition this distinction does not seem to be crucial, as one and the same spatial notion, the void, is used to separate mathematical entities as well as sensible things.[3] So we should leave it open as a possibility that our distinction between physical and geometrical space may not be a distinction the ancients would draw.

It might seem that they are compelled to make such a distinction given that the prevailing notions of the universe as the most comprehensive physical space assume it to be finite and bounded, whereas (Euclidean) mathematical space is infinite. However, while this sounds like a screaming tension to us, there does not seem to be an explicit discussion of it in preclassical and classical ancient times; spatial notions are just used by mathematicians as well as by natural philosophers. And while we find an explicit discussion of physical space in Aristotle, we do not have any evidence of a discussion of space by the mathematicians during these times.[4]

1.2. A Brief Look at Some of the Main Spatial Terms

1.2.1. *TO KENON*

Kenos is normally translated as "empty" or "void," the nominalization of this adjective, *to kenon*, as "the void."[5] In common language only the adjective is used, while the substantive expression is tied to philosophical contexts. In its first philosophically interesting use, with Melissus

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3 DK 58 B 30.

4 As Max Jammer, *Concepts of Space: The History of Theories of Space in Physics* (Chelmsford, MA: Courier, 2013) points out, also the anisotropy of space with Aristotle and the inhomogeneity of space with Plato seem to make physical space incompatible with the geometrical space used in Greek mathematics (if we can take Euclid's *Elements* as evidence). Aristotle does of course distinguish between physical and mathematical things, but since mathematica are abstractions from physical things, mathematical space is not a separate space over and above the physical one. And for him mathematical space is in fact not infinite but just as big as we need, so he does not face a discrepancy between a finite physical world and an infinite mathematical space.

5 For the discussion of *to kenon, chôra*, and *topos* I am especially indebted to Keimpe Algra's *Concepts of Space in Greek Thought* (Leiden: Brill, 1994), chapter 2.

and the atomists, *to kenon* is a physical interpretation of the Eleatic notion of nonbeing, what is not. In accordance with the multifaceted use of nonbeing, *to kenon* gets used in different ways by the atomists, and Aristotle takes up these different notions in his refutation of the void in the *Physics*, where he also points out potential conflicts between them.[6]

In general, *to kenon* means "emptiness"; as such it can refer either to (1) empty extension or space or to (2) a specific empty thing or part of a thing (like an empty vessel).[7] But it can also refer to (3) space or place as such.[8]

1.2.2. *CHÔRA* AND *TOPOS*

Chôra is a two- or three-dimensional extension, which can be occupied. The basic meaning of *chôra* is "land," "region," "ground"; when it is applied to a smaller extension it can also mean "stretch," "field," or "place"—it points out the place where one is or should be. *Topos* is largely used synonymously with *chôra*. But while *chôra* already appears in Homer, *topos* cannot be found before Aeschylus.[9]

As for the relationship of *chôra* and *topos*, people like to translate *chôra* as "space" and *topos* as "place." However, there is no one-to-one match between *topos* and place and *chôra* and space; the adequate translation depends very much on the context.[10] When both are used

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6 For example, when he uses the notion of a void as an occupier of space against the notion of the void as itself space in 217a4 ff. Aristotle, *Aristotle's Physics: A Revised Text*, ed. W. D. Ross (Oxford: Clarendon Press, 1936).

7 In the first sense it is independent of any possible thing that may be in it; in the second sense, by contrast, it is dependent on the thing that is empty (e.g., on the vessel).

8 Cf., for example, Aristotle's report on such a usage in *Physics*, 214a14.

9 For *chôra* cf., for example, Homer, *Iliad* XXIII, 521, or *Od*yssey VIII, 573; for *topos*, Aeschylus, *The Persians*, 769.

10 In *Timaeus* 19a, for example, Plato talks about the *chôra* of a person in a class society dependent on his ability; we would probably translate it as the "place" (rather than "space") that the less deserving should change with the more deserving. For the relation between *chôra* and *topos* see especially Algra, *Space*, 33–38; also Benjamin Morison, *On Location: Aristotle's Concept of Place* (Oxford: Oxford University Press, 2002), 23, 121–32.

together, *topos* may denote a part of *chôra*. But in contrast to *chôra, topos* can also be used to denote relative location or position in relation to a surrounding. And *topos* is often understood to be fully occupied place, while *chôra* as only partly occupied. *Topos* can also denote the underlying extension not of individual things but of the whole universe and is thus used for indicating what we would call "space."

With the Hellenistic schools, the Epicureans and the early Stoics, *chôra, topos*, and *kenon* become technical terms. *Topos* refers to the space that is occupied by a body and *kenon* to the space that is not occupied by a body. For the Epicureans *chôra* indicates the space a body is moving through,[11] while for the Stoics *chôra* is an interval partly occupied by a body and partly unoccupied.[12] But the time we are looking at, which is before the early Stoics and Epicureans, does not use these terms in a fixed, technical way.

1.2.3. *DIASTÊMA*

Diastêma basically means "distance." It can refer to distance in general or to a specific distance, as, for example, the distance and hence interval between notes in music or the distance between the center of a circle and any point on its circumference, hence the radius. These distances need not be spatial; for example, the *diastêma* between two numbers such as 1 and 2 is what we would understand as the interval between the two numbers.[13] But it is prominently used also for spatial extension, such as the spatial extension between bodies, and also covers what we would call spatial dimensions: length, breadth, and depth.[14]

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11 In this way the Middle Ages also employed the distinction between place, which refers to location, and space, which is employed in contexts of motion.

12 Cf., for example, Sextus Empiricus, *Adversus mathematicos* 10.2–4, in *Sexti Empirici Opera* (Teubner: Leipzig, 1914–61); Richard Bett, ed. and trans., *Sextus Empiricus: Against the Logicians* (Cambridge, UK: Cambridge University Press, 2005).

13 See, for example, Aristotle, *Physics* 202a18.

14 See, for example, Aristotle, *Physics*, 209a4.

Looking at some of the main spatial terms used by the Greeks up to Aristotle, we see that the following spatial ideas are of importance: the term *diastêma* expresses the idea of a distance; *chôra* and *topos* refer to the notion of a certain extended area, but also to a specific point or section within such an area; and the term *kenos* conveys the idea that there needs to be something that allows for motion and separation.

2. The Very Beginning: Space Is Not Clearly Distinguished from Other Magnitudes

2.1. Hesiod

In Hesiod we find the first significant image of space in Greek literature: chasm. But we are also confronted with several passages that do not clearly distinguish between space and time. Right from the very beginning of Hesiod's *Theogony*—his cosmogony and genealogy of the gods—temporal and spatial notions are closely intertwined:

> In truth, first of all Chasm came to be, and then broad-breasted Earth, the ever immovable seat of all the immortals who possess snowy Olympus's peak and murky Tartarus in the depth of the broad-breasted earth, and Eros. . . .
>
> From Chasm Erebos and black Night came to be; and then Aether and Day came forth from Night, who conceived and bore them after mingling in love with Erebos. Earth first of all bore starry Sky, equal to herself, to cover her on every side, so that she would be the ever immovable seat for the blessed gods. (lines 116–27, Most's translation)

First of all Chasm came to be. A chasm (Greek, χάος) usually is some gap within a (or between two) spatially extended things.[15] Hesiod does not determine the chasm in any way further, but it seems to

15 The Greek term χάος is often translated as "chaos." However, in his translation of the *Theogony* Most rightly points out that this misleadingly suggests a jumble of disordered matter. By contrast,

be something we would characterize as spatial. Also Aristotle in his *Physics* understands it as a first notion, or proto-notion, of space, since it shows that we need something *where* all other things can then come into being. This fits also with the next thing that comes into being, Gaia, "broad-breasted earth." Thus we start out with the spatial dimensions of depth (chasm) and breadth (broad-breasted). Presumably, if earth has breadth, she also has length, so that we have all three spatial dimensions (or, as is more common in ancient times, all six spatial extensions, since each of our three dimensions has a to and fro).[16] In addition, earth also possesses the height of Mount Olympus, which makes her "the ever immovable seat of all the immortals"; she provides *location* for the gods. Thus also the gods are given a space, snowy Olympus, before they come into being.

Earth is the main spatial reference point: it is from earth that we can say Tartarus is below and, later on, that Ouranos is above. However, while earth is seen as something clearly limited,[17] in contrast to the indeterminate Tartarus, we are not given any clear shape and size of Gaia;[18] all we hear is that Gaia is encircled by Oceanus.

While it seems we get only a spatial setup of the universe in the beginning, it is actually from the very first spatial notion, chasm, that we get the first temporal notion: from chasm *night* came into being. And from night and darkness (Erebos)[19] day is generated, so something else that we would characterize as temporal. There is no indication in the

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Hesiod's term indicates a gap or opening; cf. also Geoffrey Stephen Kirk, John Earle Raven, and Malcolm Schofield, eds., *The Presocratic Philosophers: A Critical History with a Selection of Texts* (Cambridge, UK: Cambridge University Press, 1983), 37 (hereafter KRS), who point out that the term "chaos" comes from the root *cha*, which means "gape," "gap," or "yawn."

16 Cf., for example, Aristotle's *Physics*, which talks about three dimensions (*Physics* 209a4–6) or six extensions (*Physics* 208b12–14). The dimension of depth has the up and the down, etc.

17 She is limited above by Ouranos, and for her below, we are told in lines 621–22 that Obriareus, Cottos, and Gyges have to dwell under the earth, at the edge or limits of the earth. By contrast, Pontos (sea) is explicitly called boundless (*apeiron*) in line 678.

18 Gaia is on the one hand treated as a person, on the other hand as a place, in which, for example, Zeus can be hidden as in a container (lines 479–83).

19 Erebos is also seen as a *place*; see line 669 and Homer, *Odyssey* X, 528 and XII, 81.

text that now the dimension we are looking at is changing; rather, in the same genealogical way as one spatial notion comes to be from another (e.g., Ouranos from Gaia, heaven from earth), so a temporal notion like night comes to be from the spatial chasm.

That time and space are not strictly distinguished is also clear from other passages in Hesiod. For example, in *Theogony* 721–25 we read:

> For so far is it from earth to murky Tartarus. For a brazen anvil falling down from heaven nine nights and days would reach the earth upon the tenth: and again, a brazen anvil falling from earth nine nights and days would reach Tartarus upon the tenth. Round it runs a fence of bronze, and night spreads in triple line all about it like a neck-circlet, while above grow the roots of the earth and unfruitful sea. (Hugh G. Evelyn-White's translation with alterations)

Tartarus is described as being encircled by a fence—"round it runs a fence of bronze"—which seems normal for something spatial. But then we hear that "night spreads in triple line all about it like a neck-circlet." Thus something that is usually seen as a temporal unit, night, is here treated as something spatial.

Furthermore, the way in which spatial distances between heaven and earth and between earth and Tartarus are determined is in terms of time, namely in terms of anvil days: ten anvil days from sky to earth and ten more from there to Tartarus. An anvil day presumably is the distance an anvil will fall in a day.

You might think that "day" here is a spatial unit, since we are talking about a day in the sense of how much space an anvil covers in a day. Thus a day seems to be a way to determine a unit of space. After all, this is before the time of having an Ur-meter in Paris, with the help of which at least all scientific measurements are done. So perhaps this is a way for Hesiod to indicate for people in Boeotia, as well as in Athens, in Asia Minor, and on the Peloponnese how long this distance is: it is awfully long.[20] Of course, nobody knew how far an anvil would fall in a day. (How would they have found out?) So this is not really an easier way to determine a certain spatial extension. And even if we treat it as straightforwardly a unit of space, it would still originally be some temporal unit that was then turned into a spatial one.

Summing up, we can say that there are three main spatial notions in Hesiod:

1. With chasm we get the idea of a *where* in which things can come into being. But it is a mere opening that is in no way further determined and thus does not provide any further spatial orientation.
2. With Tartarus and Ouranus we are given a basic below and above and can determine a motion's up and down.
3. With earth all three dimensions are fully unfolded. It is extension that is in the foreground and the *possibility* of location, not so much actually tracing down a specific spot where something is situated.

In spite of these spatial notions, we saw that Hesiod does not strictly distinguish between spatial and temporal notions, as becomes especially clear when we are dealing with limits. That a clear-cut distinction between time and space might not be something regarded as a matter of fact or even desirable we also see in Anaximander.

2.2. Anaximander and the Early Cosmologists

Cosmology can be seen as a, if not the, starting point of philosophy. Thales, the first philosopher, allegedly predicted a solar eclipse, and

20 It is not uncommon also in later times to use the time a normal journey would take in order to indicate a distance; cf., for example, Herodotus II, 5, where he indicates the part above Lake Moeris that has been gained from the river as "up to a three-day sail."

an important part of what we know about the Ionian thinkers is how they thought the universe was set up. Cosmology naturally not only includes some thinking about space, the spatial arrangement of the world, but it also brings spatial and temporal phenomena together: the locomotion of heavenly bodies and thus a process in space is used to determine temporal units and to calculate time.

Many cosmologies work with the idea of a clear center of the universe, usually the earth. This center may be loaded with a special value, as we see, for example, with the Pythagoreans;[21] it is usually defined not in relation to something else but as an absolute center. But already in Anaximander—and later on also in the atomists—we seem to encounter the idea of infinitely many worlds;[22] in this case we can talk about a center only relative to our world, not of the universe as such.

Thales not only gives an account of the position of the earth in the universe—it is floating on water, that is why it is not "falling down"—but he also seems to have raised an important question for many philosophers to come, namely whether there is one basic entity, principle, or element that can help explain the plurality of phenomena in our world. Thales thinks that there is such a principle and that it is water, which can then turn into the other elements.

To judge from Aristotle's testimony (*Physics* 204b22–29), Anaximander seems to have reacted to this basic question of Thales by criticizing Thales's attempt to establish water as this basic principle: water cannot be a suitable first principle since it is one specific element and thus does not qualify to give rise also to the other elements. If water itself is seen to be cold and wet, for example, it is unclear how its opposite, the dry and warm stuff, can come out

21 However, since the center in the universe is the most valuable place, it cannot be occupied by earth for the Pythagoreans, but has to be occupied by what itself is most valuable: by fire.

22 Though there is some dispute among scholars whether Anaximander did indeed assume infinitely many worlds and whether, if he did so, these infinitely many worlds are coexistent or successive; cf. KRS 124ff.