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The aim of this book is to explain the shape of Greek mathematical thinking. It can be read on three levels: first as a description of the practices of Greek mathematics; second as a theory of the emergence of the deductive method; and third as a case-study for a general view on the history of science. The starting point for the enquiry is geometry and the lettered diagram. Reviel Netz exploits the mathematicians' practices in the construction and lettering of their diagrams, and the continuing interaction between text and diagram in their proofs, to illuminate the underlying cognitive processes. A close examination of the mathematical use of language follows, especially mathematicans' use of repeated formulae. Two crucial chapters set out to show how mathematical proofs are structured and explain why Greek mathematical practice manages to be so satisfactory. A final chapter looks into the broader historical setting of Greek mathematical practice.

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IDEAS IN CONTEXT 51

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THE SHAPING OF DEDUCTION IN GREEK MATHEMATICS

A Study in Cognitive History

REVIEL NETZ

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To Maya

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Preface

This book was conceived in Tel Aviv University and written in the University of Cambridge. I enjoyed the difference between the two, and am grateful to both.

The question one is most often asked about Greek mathematics is: 'Is there anything left to say?' Indeed, much has been written. In the late nineteenth century, great scholars did a stupendous work in editing the texts and setting up the basic historical and mathematical framework. But although the materials for a historical understanding were there, almost all the interpretations of Greek mathematics offered before about 1975 were either wildly speculative or ahistorical. In the last two decades or so, the material has finally come to life. A small but highly productive international community of scholars has set up new standards of precision. The study of Greek mathematics today can be rigorous as well as exciting. I will not name here the individual scholars to whom I am indebted. But I can – I hope – name this small community of scholars as a third institution to which I belong, just as I belong to Tel Aviv and to Cambridge. Again I can only express my gratitude.

So I have had many teachers. Some were mathematicians, most were not. I am not a mathematician, and this book demands no knowledge of mathematics (and only rarely does it demand some knowledge of Greek). Readers may feel I do not stress sufficiently the value of Greek mathematics in terms of mathematical content. I must apologise – I owe this apology to the Greek mathematicians themselves. I study form rather than content, partly because I see the study of form as a way into understanding the content. But this content – those discoveries and proofs made by Greek mathematicians – are both beautiful and seminal. If I say less about these achievements, it is because I have looked elsewhere, not because my appreciation of them is not as keen as it should be. I have stood on the shoulders of giants –

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to get a good look, from close quarters, at the giants themselves. And if I saw some things which others before me did not see, this may be because I am more short-sighted.

I will soon plunge into the alphabetical list. Three names must stand out – and they happen to represent the three communities mentioned above. Sabetai Unguru first made me read and understand Greek mathematics. Geoffrey Lloyd, my Ph.D. supervisor, shaped my view of Greek intellectual life, indeed of intellectual life in general. David Fowler gave innumerable suggestions on the various drafts leading up to this book – as well as giving his inspiration.

A British Council Scholarship made it possible to reach Cambridge prior to my Ph.D., as a visiting member at Darwin College. Awards granted by the ORS, by the Lessing Institute for European History and Civilization, by AVI and, most crucially, by the Harold Hyam Wingate Foundation made it possible to complete graduate studies at Christ's College, Cambridge. The book is a much extended and revised version of the Ph.D. thesis, prepared while I was a Research Fellow at Gonville and Caius College. It is a fact, not just a platitude, that without the generosity of all these bodies this book would have been impossible. My three Cambridge colleges, in particular, offered much more than can be measured.

I owe a lot to Cambridge University Press. Here, as elsewhere, I find it difficult to disentangle 'form' from 'content'. The Press has contributed greatly to both, and I wish to thank, in particular, Pauline Hire and Margaret Deith for their perseverance and their patience.

The following is the list – probably incomplete – of those whose comments influenced directly the text you now read (besides the three mentioned already). My gratitude is extended to them, as well as to many others: R. E. Aschcroft, Z. Bechler, M. F. Burnyeat, K. Chemla, S. Cuomo, A. E. L. Davis, G. Deutscher, R. P. Duncan-Jones, P. E. Easterling, M. Finkelberg, G. Freudental, C. Goldstein, I. Grattan-Guinness, S. J. Harrison, A. Herreman, J. Hoyrup, E. Hussey, P. Lipton, I. Malkin, J. Mansfeld, I. Mueller, J. Ritter, K. Saito, J. Saxl, D. N. Sedley, B. Sharples, L. Taub, K. Tybjerg, B. Vitrac, L. Wischik.[1]

[1] I have mentioned above the leap made in the study of Greek mathematics over the last two decades. This owes everything to the work of Wilbur Knorr, who died on 18 March 1997, at the age of 51. Sadly, he did not read this book – yet the book would have been impossible without him.

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Abbreviations

GREEK AUTHORS

Abbreviation	Work (standard title)	Author
de Aedific.	*de Aedificiis*	Procopius
Amat.	*Amatores*	[Plato]
APo.	*Analytica Posteriora*	Aristotle
APr.	*Analytica Priora*	Aristotle
Av.	*Aves*	Aristophanes
Cat.	*Categoriae*	Aristotle
CF	*On Floating Bodies*	Archimedes
CS	*On Conoids and Spheroids*	Archimedes
DC	*Measurement of Circle*	Archimedes
D.L.	Lives of Philosophers	Diogenes Laertius
EE	*Ethica Eudemia*	Aristotle
El. Harm.	*Elementa Harmonica*	Aristoxenus
de Eloc.	*Demetrius on Style*	Demetrius
EN	*Ethica Nicomachea*	Aristotle
Epin.	*Epinomis*	[Plato] (Plato?)
Euthd.	*Euthydemus*	Plato
Euthyph.	*Euthyphro*	Plato
Grg.	*Gorgias*	Plato
HA	*Historia Animalium*	Aristotle
Hip. Mai.	*Hippias Maior*	Plato
Hip. Min.	*Hippias Minor*	Plato
In de Cael.	*In Aristotelis de Caelo Commentaria*	Simplicius
In Eucl.	*In Euclidem*	Proclus
In Phys.	*In Aristotelis Physica Commentaria*	Simplicius

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Abbreviation	Work (standard title)	Author
de Int.	*de Interpretatione*	Aristotle
In SC	*In Archimedes' SC*	Eutocius
In Theaetet.	*Anonymi Commentarius In Platonis Theaetetum*	Anonymous
Lgs.	*de Legibus*	Plato
Mech.	*Mechanica*	[Aristotle]
Mem.	*Memorabilia*	Xenophon
Metaph.	*Metaphysica*	Aristotle
Meteor.	*Meteorologica*	Aristotle
Meth.	*The Method*	Archimedes
Nu.	*Nubes*	Aristophanes
Ort.	*Risings and Settings*	Autolycus
Parm.	*Parmenides*	Plato
de Part.	*de Partibus Animalium*	Aristotle
PE	*Plane Equilibria*	Archimedes
Phaedr.	*Phaedrus*	Plato
Phys.	*Physica*	Aristotle
QP	*Quadrature of the Parabola*	Archimedes
Rep.	*Republica*	Plato
SC	*On Sphere and Cylinder*	Archimedes
SE	*Sophistici Elenchi*	Aristotle
SL	*Spiral Lines*	Archimedes
Theaetet.	*Theaetetus*	Plato
Tim.	*Timaeus*	Plato
Vit. Alc.	*Vita Alcibiadis*	Plutarch
Vita Marc.	*Aristotelis Vita Marciana*	Anonymous
Vita Pyth.	*de Vita Pythagorica*	Iamblichus

ROMAN AUTHORS

Abbreviation	Work (standard title)	Author
Ann.	*Annales*	Tacitus
Nat. Hist.	*Naturalis Historia*	Pliny the Elder
ND	*de Natura Deorum*	Cicero
de Rep.	*de Republica*	Cicero
Tusc.	*Tusculanae Disputationes*	Cicero

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DOCUMENTARY SOURCES

Abbreviation	Standard title
BGU	*Berliner griechische Urkunden*
FD	*Fouilles de Delphes*
ID	*Inscriptions Délos*
IG	*Inscriptionae Graecae*
IGChEg.	*Inscriptionae Graecae* (Christian Egypt)
IK	*Inschriften aus Kleinasien*
Ostras	*Ostraka* (Strasburg)
P. Berol.	*Berlin Papyri*
PCair.Zen.	*Zenon Papyri*
PFay.	*Fayum Papyri*
P. Herc.	*Herculaneum Papyri*
PHerm Landl.	*Landlisten aus Hermupolis*
POxy.	*Oxyrhynchus Papyri*
YBC	*Yale Babylonian Collection*

OTHER ABBREVIATIONS

Abbreviation	Reference (in bibliography)
CPF	*Corpus dei Papiri Filosofici*
DK	Diels–Kranz, *Fragmente der Vorsokratiker*
KRS	Kirk, Raven and Schofield (1983)
L&S	Long and Sedley (1987)
LSJ	Liddell, Scott and Jones (1968)
Lewis and Short	Lewis and Short (1966)
TLG	*Thesaurus Linguae Graecae*
Usener	Usener (1887)

NOTE ON GENDER

When an indefinite reference is made to ancient scholars – who were predominantly male – I use the masculine pronoun. The sexism was theirs, not mine.

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The Greek alphabet

Capital *approximately the form used in ancient writing*	Lower case *a form used in modern texts*	Name of letter
Α	α	Alpha
Β	β	Bēta
Γ	γ	Gamma
Δ	δ	Delta
Ε	ε	Epsilon
Ζ	ζ	Zēta
Η	η	Ēta
Θ	θ	Thēta
Ι	ι	Iōta
Κ	κ	Kappa
Λ	λ	Lambda
Μ	μ	Mu
Ν	ν	Nu
Ξ	ξ	Xi
Ο	ο	Omicron
Π	π	Pi
Ρ	ρ	Rhō
Σ	σ ς[1]	Sigma
Τ	τ	Tau
Υ	υ	Upsilon
Φ	φ	Phi
Χ	χ	Chi
Ψ	ψ	Psi
Ω	ω	Ōmega

[1] A modern form for the letter in final position.

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Note on the figures

As is explained in chapter 1, most of the diagrams in Greek mathematical works have not yet been edited from manuscripts. The figures in modern editions are reconstructions made by modern editors, based on their modern understanding of what a diagram should look like. However, as will be argued below, such an understanding is culturally variable. It is therefore better to keep, as far as possible, to the diagrams as they are found in Greek manuscripts (that is, generally speaking, in Byzantine manuscripts). While no attempt has been made to prepare a critical edition of the Greek mathematical diagrams produced here, almost all the figures have been based upon an inspection of at least some early manuscripts in which their originals appear, and I have tried to keep as close as possible to the visual code of those early diagrams. In particular, the reader should forgo any assumptions about the lengths of lines or the sizes of angles: unequal lines and angles may appear equal in the diagrams and vice versa.

In addition to the ancient diagrams (which are labelled with the original Greek letters), a few illustrative diagrams have been prepared for this book. These are distinguished from the ancient diagrams by being labelled with Latin letters or with numerals.

While avoiding painterly effects, ancient diagrams possess considerable aesthetic value in their austere systems of interconnected, labelled lines. I wish to take this opportunity to thank Cambridge University Press for their beautiful execution of the diagrams.

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