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Classical Mathematics in the Classical Mediterranean

REVIEL NETZ

This article offers two maps describing the geographical distribution of mathematicians in antiquity (up to the end of the fifth century AD). Following these maps, a few possible directions for study are suggested. The basic structure of the geographical distribution in this case is identified as 'single centre plus peripheral scatter', the centre being first Athens, and later Alexandria. Questions are raised concerning the relative roles of centre and periphery, the identity of the centres, the geographical areas where the periphery is located, and the relations between this distribution and others.

This article offers and discusses a set of two maps that describe the distribution of mathematicians in antiquity (up to the end of the fifth century AD). The first map, 'Before Alexandria' – before the foundation of Alexandria (331 BC) – is centred on the Aegean. The second, 'After Alexandria', is centred on the eastern Mediterranean. On each map, cities are named, with numbers written next to them. These are the ordinal numbers assigned to individual mathematicians in the catalogue accompanying the maps. (Note that a single catalogue covers both.) The catalogue comprises a list of cities, arranged alphabetically; under each city, the names are arranged chronologically.

These maps may prove useful for specialists, as reference material for further study. They may also have a wider interest. Such maps make it possible to raise a number of questions concerning the long duration dimension of intellectual history. When we produce such a map, we derive a distribution in space and time. We can then ask, why do we have this particular distribution and not another? Why is the centre located here and not there? Why have a centre at all? In the remarks following the catalogue, such questions are raised briefly, and some tentative directions for seeking answers are offered. This study concentrates on classical Greek mathematics; similar studies could be made for different areas and periods.¹

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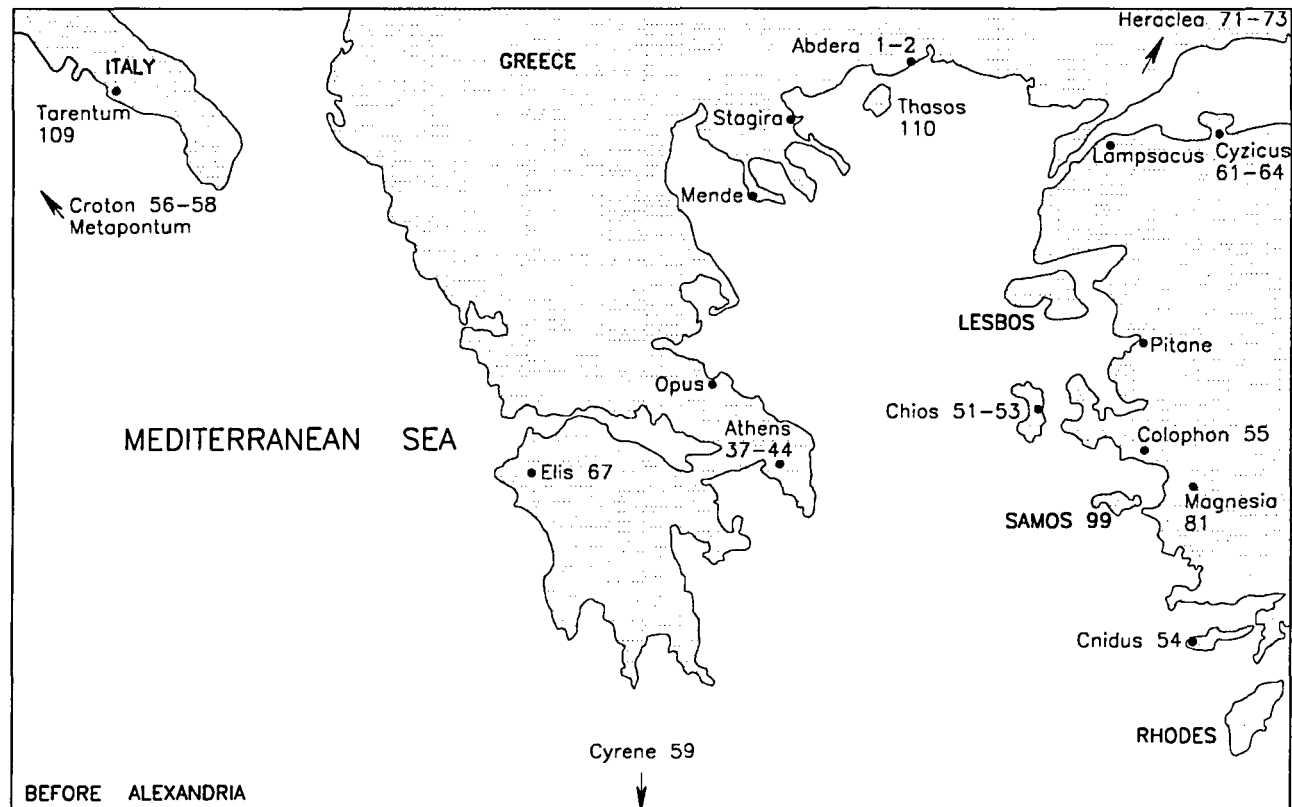
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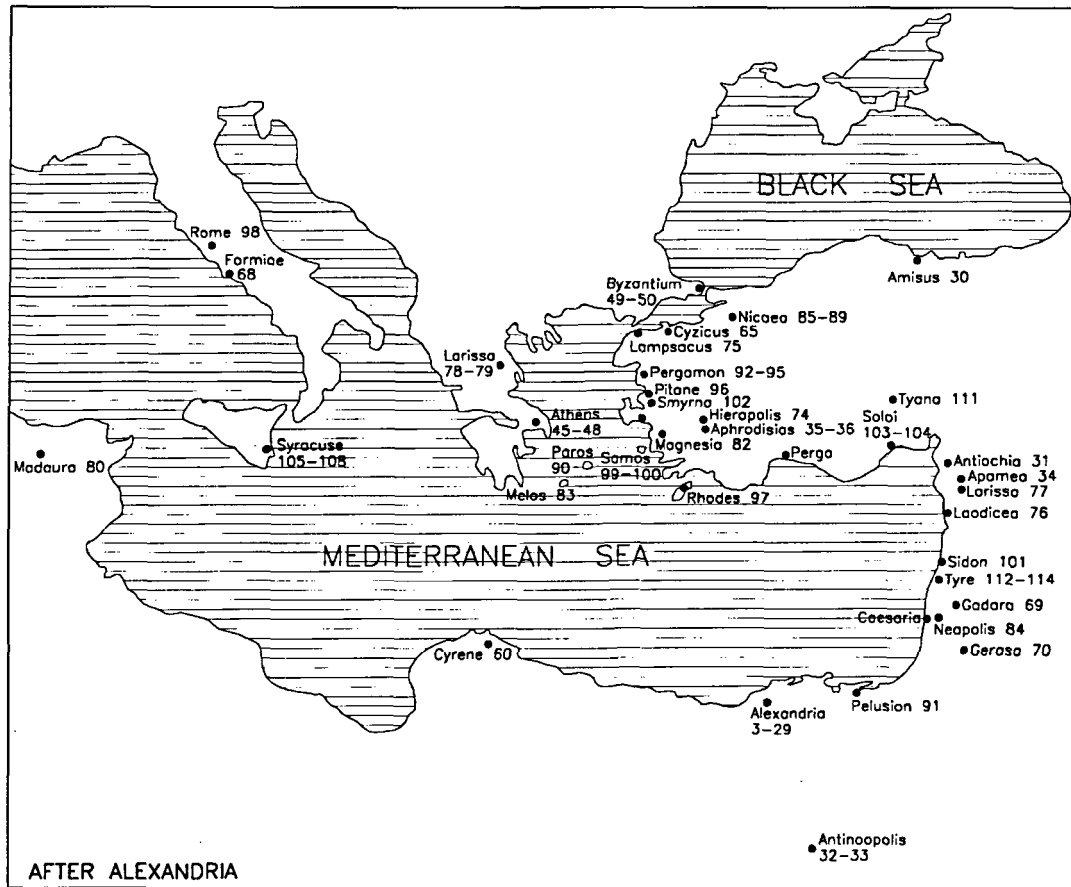
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MAP 1



MAP 2



any other activity, space or time for a case study), the case of classical mathematics is of special interest. First, in many ways classical mathematics may be seen as the foundation of Western science. Suffice it to note that among the figures surveyed below are Euclid (author of the *Elements*, the most influential scientific textbook in the West) and Archimedes (whose work provided the inspiration for much of early modern science). Furthermore, classical mathematics is a relatively self-contained and easily defined phenomenon. It is not difficult to offer a criterion for deciding whether an individual was or was not a mathematician (this criterion is discussed briefly below).

The information in the catalogue is organized as follows:

1. First, the ordinal number of the individual.²
2. Before a name, a question mark may appear, for example '14. ?Sosigenes'. This reflects a greater than usual doubt over the location of the individual.
3. The name may be followed by a subscript number. This is the number of the Realencyclopädie (Pauly-Wissowa) article dedicated to the individual.³ The absence of any subscript indicates either that the individual is not covered by the Realencyclopädie (in which case some reference to a classical source is provided), or that there is only one Realencyclopädie article with that name.
4. Following is an indication of chronology. All dates are rounded to the nearest multiple of 50.⁴ The date is meant to be the *acme*, the peak of one's career. Most dates are tentative; truly dubious dates are followed by a question mark. A '±' is used (in an obvious way), when necessary, to represent the *post quem* and *ante quem* (the date supplied in such cases is simply the arithmetical average of the *termini*). Such *termini* are provided only when the difference between them is 400 years or less; otherwise, it is better to concede defeat and consider the date completely unknown.
5. Finally, the query 'Math?' may appear. This signifies a higher degree of doubt as to whether the person involved was a mathematician; in some cases, there may be doubt as to the very existence of the individual.

This of course raises the issue of definition. Whoever has written (or perhaps merely produced orally) an argument showing the validity of some claim, using the techniques we identify with Greek mathematics (a lettered diagram, a specific mode of language use), is, in my opinion, a mathematician. A group is identified according to its *practice*. Astronomical observers, calculators, astrologers: if they do not produce proofs, they are not

mathematicians. I believe this is a concept with which the Greeks would have identified. First, we have a substantial corpus of writings surviving from antiquity, written by a few dozen individuals, all written within the same style, using the same set of techniques. This leads us to believe that this style was an actor-concept. Further, it has been argued that a defining aspect of Greek culture was the centrality of the modes of persuasion.⁵ This was a culture in which argument and reasoning were central concepts. It is therefore natural to identify a specific cultural activity within this broad context, according to the modes of persuasion it adopts. But, finally, to be on the safe side, the definition is used very leniently. Whenever there is even a remote possibility that the individual in question was a mathematical practitioner, he or she is included, sometimes with the 'Math?' qualification. Note, however, my scepticism concerning the earliest period sometimes mentioned in the context of Greek mathematics, the period of Pythagorases and Thaleses. Following Burkert,⁶ such figures are not included in this survey.⁷

The catalogue contains 144 entries. What kind of a sample is that, relative to what we have lost? I argue elsewhere⁸ that this is a very substantial sample. When we cross-section two different ancient sources, we always find a surprising degree of agreement, as if they all seem to know the same limited pool of mathematicians.⁸ And, most important, there is the qualitative fact that *groups* of mathematicians are rare in our evidence for Greek mathematics.⁹ The Greek mathematician does not travel in packs. We see him on his own; sometimes corresponding with a distant co-enthusiast; getting into a real panic when this co-enthusiast passes away. I have discussed such evidence elsewhere.¹⁰ My conclusion is that there were about 1,000 mathematicians, at most, in antiquity. A rule of thumb, possibly, will be that our sample is an order of magnitude short of reality. Multiplying the various numbers we have by ten, we get a more or less workable upper limit to the real numbers.

The following, however, does not lay much stress on such absolute numbers. Absolute numbers are absolute uncertainties. Yet the maps do provide us, with or without such numbers, with some interesting qualitative facts. Following the maps and the catalogue are a few speculative remarks.

A final disclaimer: such catalogues must be tentative. It is to be hoped that the results will not have to be radically altered through corrections to the catalogue, but also that its publication will elicit any necessary clarifications.

Abdera				Antinoopolis			
1	Democritus ₆ ¹¹	400-		32	Serenus ₁₀ ⁴⁴	350+ (?)	
2	Bion ₁₁ ¹²	400-		33	?Peitho ⁴⁵	350+ (?)	Math?
Alexandria				Apamea (Orontes)			
3	Aristylus ₃ ¹³	300-		34	Posidonius ₃ ⁴⁶		
4	Euclid ₁ ¹⁴	300-			(v. Rhodes)	100-	
5	Timocharis ₁ ¹⁵	300-		Aphrodisias			
6	Ctesibius ₂ ¹⁶	250-		35	Adrastus ₇ ⁴⁷	150+	Math?
7	Dionysius ₁₄₃ ¹⁷	250-		36	?Sosigenes ₇ ⁴⁸	150+	Math?
8	Eratosthenes ₄ ¹⁸			Athens			
	(v. Cyrene)	250-		37	Euctemon ₁₀ ⁴⁹	450-	Math?
	Dositheus ₁ ¹⁹			38	Meton ₂ ⁵⁰	450-	
	(v. Pelusion)	250-?	Math?		Hippocrates ₁₄ ⁵¹		
	Conon ₁₁ ²⁰				(v. Chios)	450-	
	(v. Samos)	250-			Theodorus ₃₁ ⁵²		
9	Apollonius ₁₁₂ ²¹				(v. Cyrene)	400-	
	(v. Perga)	200-		39	Theaetetus ₂ ⁵³	400-	
10	Apollonius ₂₂ ²²	200-	Math?	40	Aristotle ₁₈ ⁵⁴		
11	Demetrius ₁₁₆ ²³	150-			(v. Stagira)	350-	
		(±200)		41	?Dinostratus ₂ ⁵⁵	350-	
12	Hypsicles ₂ ²⁴	150-		42	?Menaechmus ₃ ⁵⁶	350-	
13	Diodorus ₅₃ ²⁵	50-		43	Philippus ₄₂ ⁵⁷		
14	?Sosigenes ₂₆ ²⁶	50-?			(v. Opus, Mende)	350-	
15	Thrasyllus ₂₇ ²⁷	0	Math?	44	Xenocrates ₄ ⁵⁸	350-	Math?
16	Hero ₃ ²⁸	50+(?)			Callipus		
17	Menelaus ₁₆ ²⁹	100+			(v. Cyzicus)	350-	
18	Ptolemy ₆₆ ³⁰	150+			Eudoxus ₈ ⁵⁹		
19	Diophantus ₁₈ ³¹	250+(±100)			(v. Cnidus)	350-	
20	Anatolius ₅ ³²				Heraclides ₄₅ ⁶⁰		
	(v. Caesaria)	300+			(v. Heracleia)	350-	
21	Hierius ₃₃ ³³	300+	Math?	45	?Demetrius ₁₁₅ ⁶¹	300-	
22	?Megethio ₃₄ ³⁴	300+	Math?	46	Eudemus ₁₁ ⁶²		
23	Pandrosion	300+			(v. Rhodes)	300-	
24	Pappus ₂ ³⁵	300+		47	Hipponicus ₆₃ ⁶³	300-	
25	Hermodorus ₃₆ ³⁶	350+			Apuleius ₉ ⁶⁴		
26	Theon ₁₅ ³⁷	350+			(v. Madaura)	150+	
27	Hero ₆ ³⁸	400+	Math?		Porphyrus ₂₁ ⁶⁵		
28	Hypatia ₃₉ ³⁹	400+			(v. Tyre)	250+	
	?Cratistus			48	?Cratistus ₆₆ ⁶⁶		
	(v. Athens)	450+			(v. Alexandria)	450+	
29	?Dionysius ₁₄₇ ⁴⁰	?			Domninus ₄ ⁶⁷		
Amisus (Pontus)					(v. Larisa)	450+	
30	Demetrius ₁₁₇ ⁴¹	250-(±200)	Math?		Prollus		
Antiochia					(v. Byzantium)	450+	
	Philonides ₅ ⁴²			Byzantium			
	(v. Laodicea)	200-		49	Philo ₄₈ ⁶⁸	200-	
31	Carpus ₄₃ ⁴³	100+					

50	Proclus ₄ (v. Athens)	450+		Gadara			
				69	Philo ₅₀ ⁸⁴	100+	
Caesaria (Palestine)				Gerasa			
	Anatolius ₁₅ (v. Alexandria)	300+		70	Nicomachus ₂₁ ⁸⁵	100+	
Chios				Heracleia (Pontus)			
51	Hippocrates ₁₄ (v. Athens)	450-		71	Bryson ₂ ⁸⁶	400-	
52	Oenopides ⁶⁹	450-		72	Amyntas ₂₃ ⁸⁷	350-	Math?
53	?Aeschylus ⁷⁰	400- (?)	Math?	73	Heracledes ₄₅ (v. Athens)	350-	
Cnidus				Hierapolis			
54	Eudoxus ₈ (v. Athens)	350-		74	Aigieas ⁸⁸	?	
Colophon				Lampsacus			
55	Hermotimus ₃ ⁷¹	350-		75	Polyaenus ₆ ⁸⁹	300-	
Croton				Laodicea (on the sea)			
56	?Eurytus ₁₀ ⁷² (v. Tarentum, Metapontum)	400-	Math?	76	Philonides ₅ (v. Antiochia)	200-	
57	?Hippasus ₁₅ ⁷³ (v. Metapontum)	400-	Math?	Larisa (Syria)			
58	?Aristaeus ⁷⁴	350- (?)		77	Domninus ₄ (v. Athens)	450+	
Cyrene				Larissa			
59	Theodorus ₃₁ (v. Athens)	400-		78	Damianus ₃ ⁹⁰	350+	
	Eratosthenes ₄ (v. Alexandria)	250-		79	Heliodorus ⁹¹	350+	Math?
60	Nicoteles ₃ ⁷⁵	250-		Madaura			
Cyzicus				80	Apuleius ₉ (v. Athens)	150+	
61	Athenaeus ₁₈ ⁷⁶	350-		Magnesia (Asia Minor?)			
62	Callipus ⁷⁷ (v. Athens)	350-		81	Theudios ⁹²	350-	
63	Helicon ₃ ⁷⁸	350-		82	[Anonymous] ⁹³	?	
64	Polemarchus ₂ ⁷⁹	350-		Melos			
65	?Protagoras ₃ ⁸⁰	300-		83	Dionysodorus ₂₀ ⁹⁴	100- (±100)	
66	?Apollodoros ₆₈ ⁸¹	?		Mende			
Elis					Philippus ₄₂ (v. Athens, Opus)	350-	
67	Hippias ₁₃ ⁸²	400-	Math?	Metapontum			
Formiae					?Eurytus ₁₀ (v. Croton, Tarentum)	400-	Math?
68	?Vitruvius ₂ ⁸³	0	Math?		?Hippasus ₁₅ (v. Croton)	400-	Math?

Neapolis (Palestine)			Sidon		
84	Marinus ₁ ⁹⁵	450+	101	Zeno ₅ ¹⁰⁹	100- Math?
Nicaea (Bithynia)			Smyrna		
85	Hipparchus ₁₈ ⁹⁶		102	Theon ₁₄ ¹¹⁰	100+
	(v. Rhodes)	150-	Soloi (Cilicia)		
86	?Theodosius ₅ ⁹⁷	100-	103	Aristotherus ₁₁ ¹¹¹	300-
87-88	Anonymi ⁹⁸	50- (?)	104	Theodorus ₃₀ ¹¹²	150-(± 200) Math?
89	?Sporus ⁹⁹	300+ (?)	Stagira		
Opus			Aristotle ₁₈		
	Philippus ₄₂		(v. Athens)		
	(v. Athens,		350-		
	Mende)	350-	Syracuse		
Paros			105	Pheidias ₁ ¹¹³	250-
90	Thymarides ¹⁰⁰	?	106	Archimedes ₃ ¹¹⁴	250-
Pelusion			107	Heraclides ¹¹⁵	250- Math?
91	Dositheus ₉		108	Scopinas ¹¹⁶	200-(±150) Math?
	(v. Alexandria)	250-?	Tarentum		
Perga			?Eurytus ₁₀		
	Apollonius ₁₁₂		(v. Croton,		
	(v. Alexandria)	200-	Metapontum)		
			109	Archytas ₃ ¹¹⁷	400- Math?
Pergamon			400-		
92	Attalus ¹⁰¹	200-	Thasos		
93	Eudemus ¹⁰²	200-	110	Leodamas ¹¹⁸	400-
94	Naucrates ₄ ¹⁰³	200-	Tyana		
95	Nicon ₁₈ ¹⁰⁴	100+	111	Philo ₅₁ ¹¹⁹	?
Math?			Tyre		
Pitane			112	Basileides ¹²⁰	200-
96	Autolycus ₉ ¹⁰⁵	300-	113	Hypsicles ₂ ¹²¹ father	200-
Rhodes			114	Porphyry ₂₁	250+
	Eudemus ₁₁		(v. Athens)		
	(v. Athens)	300-	Unlocalizable		
	Hipparchus ₁₈		115	Leon ¹²¹	400-
	(v. Nicaea)	150-	116	Neoclides ¹²²	400-
	Posidonius ₃		117	Antiphon ₁₇ ¹²³	350-
	(v. Apamea)	100-	118	Zeuxippus ¹²⁴	250-
97	?Geminus ₁ ¹⁰⁶	50- (±50)	119	Thrasydaeus ₃ ¹²⁵	200- Math?
Rome			120	Zenodorus ₃ ¹²⁶	200- (?)
98	?Andron ₁₀ ¹⁰⁷	200+	121	Charmandrus ₃ ¹²⁷	150- (±200)
Samos			122	Nicomedes ₁₆ ¹²⁸	150- (??)
99	Aristarchus ₂₅ ¹⁰⁸	300-	123	Diocles ₅₅ ¹²⁹	100- (?)
100	Conon ₁₁		124	Cleomedes ₃ ¹³⁰	150+(??)
	(v. Alexandria)	250-	125	Demetrius ₁₁₈ ¹³¹	250+

126	Heronas ¹³²	300+(±150)	Anonymous
127	Arcadius ¹³³	?	137 [Aristotle] Mechanics
128	Crates ¹³⁴	?	138 [Aristotle] Indivisible Lines
129	Erycinus ¹³⁵	?	139 [Diophantus] Polygonal Numbers
130	Heraclitus ¹³⁶	?	140 [Euclid] <i>sectio canonis</i>
131	Hippias ¹³⁷	?	141 [Euclid] Catoptrics
132	Marcellus ¹³⁸	?	142 [Euclid] Phaenomena
133	Pericles ¹³⁹	?	143 Commentary to the Almagest
134	Perseus ¹⁴⁰	?	144 Fragmentum Mathematicum
135	Plato ¹⁴¹	?	Bobiense
136	Quirinus ¹⁴²	?	Math?

REMARKS ON THE MAPS

1. *Ancient Mathematics was Scattered*

The most striking feature of the maps is how many sites they contain. For 114 localizable individuals, there are 51 sites. The scatter is noticeable in time, as well. The graph for the time-series is seen in Figure 1.

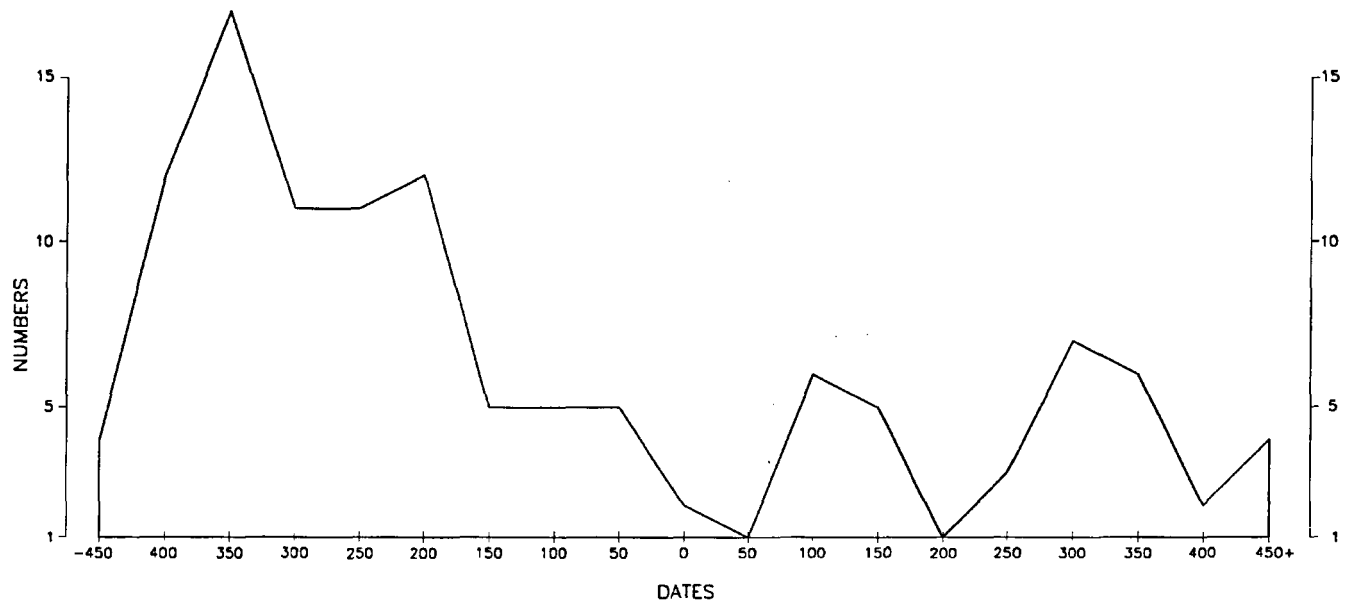
This graph, however, must be corrected for its systematic error. Ancient civilization is known to us through the preservation efforts of late antiquity. Then – in the last one or two centuries of this survey – old papyrus rolls were committed to parchment codices, and new commentaries were written on the old texts, gathering together the bits of testimony surviving from classical times. The makers of this canon were especially fixated upon what they perceived as the zenith of Greek culture, centred in fifth and fourth century Athens. Thus, our evidence has two main foci. One is the cluster of late antiquity, preserved simply because it had the luck to be there when writing on parchment codices became standard practice. The other is the fifth and fourth centuries BC, preserved because of the fascination late antiquity (and not only late antiquity) had with that period.¹⁴³ In between lie the dark ages, clearly underrepresented in our sources. Thus, the graph ought to be evened out more. We expect it to have peaks¹⁴⁴ and valleys,¹⁴⁵ but its general shape should be more balanced than it seems.

A similar bias occurs, of course, with space. Alexandrians or Athenians stand a better chance of being noted. For instance, we only know of the origins of Autolycus, in the small town of Pitane, because of his famous student Arcesilaus, who left Pitane for Athens.¹⁴⁶

We should thus assume a very sparse space–time distribution. This means that, whatever the absolute numbers, ancient mathematicians had to be active in relatively small groups. Alexandria has many names attached to it. But these names are remarkably evenly distributed over time – and we

FIGURE 1

GREEK MATHEMATICIANS – A TIME SERIES



have before us a span of some 800 years. Even if Alexandria had produced about 800 mathematicians at this period (which is probably a great exaggeration), it would have, on average, no more than 20 mathematicians working simultaneously,¹⁴⁷ something like a very modest present-day academic institute. More probably, there were only a handful of mathematicians simultaneously active in Alexandria at any given period. Pappus, of course, tells about a host of persons from around his time – so we have five Alexandrians for 300+ – but this is a mere fluke of our sources. These five may well be the only Alexandrian mathematicians of his period.

On the other hand, the concentration at Cyzicus, 350-, seems much more impressive. There we have four names, plus another at 300-, and another whose date is unknown but, given this cluster, may well belong to the same period. Unlike Alexandria and 300+, this is not a result of any bias in our sources. If anything, our sources have a bias towards Athens at this period. This, then, seems like a real mathematical institution. It is most interesting to find that we have a unique literary source (preserved in papyrus), referring to a mathematical school. And this source refers to Cyzicus at about 300-.¹⁴⁸ A surprising result: Cyzicus, a modestly important town (the most important in the Hellespont at this period), is the single institutional centre of mathematics in antiquity for which we have any strong evidence. Other than this exception, we have a very wide scatter. Still, of course, Athens and Alexandria need to be discussed. We return to them below.

This scatter does not mean Greek mathematicians were isolated. In fact, there is something fictional about my fixed places. Take Posidonius: he spent many years in most parts of the Mediterranean, travelling as far as the Atlantic. His case stands out; yet in general, Greek mathematicians were often remarkably mobile.¹⁴⁹ Many locations in my lists are no more than places of origin. Of course, these are important. It is useful to know that one could become a mathematician in small Perga.¹⁵⁰ But places of origin imply a movement from one's birthplace to the centre. Such mobility was one way of overcoming distances. Another form of mobility was writing and the use of letters – by which form we have preserved, for instance, the works of Archimedes and Apollonius. Physical mobility and correspondence have something in common. Both are signs of belonging to an elite network, extending beyond cities and frontiers. While scattered, the mathematicians always remained on the same network. We return to this in section 7 below.

2. However Scattered, a Centre and a Periphery may be Discerned.

It has been pointed out that our sources tend to favour Alexandria and Athens, and that, even so, *at any given point in time* the numbers at Alexandria are not very large. But this simply serves to remind us that Alexandria, generation by generation, somehow managed to produce new

mathematicians. And the statistics for Athens in the period 450- to 300- are just as impressive: 16 names, that is, four on average at any given point in time. The result, then, comes as no surprise. Before Alexandria, Athens is the intellectual centre; then Alexandria takes over. The two are never seriously challenged, and even the great day of Cyzicus, 350-, is overshadowed by the vast numbers for Athens at this time, with as many as eight names.

Of these 16 Athenians in the period 450- to 300-, as many as half have Athens as a second home. One wonders, indeed, how much the bias of our sources may not be deceptive here. Was Hippocrates Athens-based in any real way?¹⁵¹ Is Plato's use of Theodorus, as a teacher of mathematics to Theaetetus, really significant? Socrates asks Theodorus about Cyrene,¹⁵² and Theodorus seems more like a temporary visiting professor than an Aristotle-type metic. The striking thing, then, is that the education of Theaetetus had to rely on such visiting professors. Now, look ahead, to the year 300-. Arcesilaus, having graduated from Autolycus and Pitane, keeps up his mathematical side for a while in Athens. Why should he go to anyone but the best? He is here, the greatest Athenian mathematician of his time: Hipponicus, otherwise a complete unknown. In this world centre, in this period which interests our sources so much (here is the origin of the Hellenistic philosophical schools), the *e silentio* is powerful. Athens of 300- was no more brilliant, mathematically, than far-away Pitane. But this, of course, may already reflect the lure of Alexandria.

For the two centres will not go away. Many of the Athenian names have Athens as a second home. But is this fact itself not meaningful? The two centres are foci of attraction. Of the 32 names for Alexandria, six have another location; and, generally, Alexandrian biographies are far less known than Athenian. Cyzicus does not seem to have held the same drawing power. The greatest name associated with Cyzicus, that of Callipus, is also one of those attracted to Athens. So we have discovered a constant: the scatter does have a certain shape. There is a wide scatter. There is, however, also a centre, a single one. The classical Mediterranean could not accommodate more than one centre of attraction for mathematicians. The rise of Alexandria was the demise of Athens. We now move on to discuss these two centres, these two *modes* of centrality.

3. Before Alexandria: The Centrality of the Periphery

The phenomenon of Cyzicus – a city outside the centre which, for a short time, had become a local centre – did not repeat itself. Yet the mathematical world of the fifth and fourth centuries BC was firmly established in many small 'colonies', stretching mainly along the Aegean. Starting at Rhodes, the circuit leads us to Cnidus, to find the greatest mathematician of the

period, Eudoxus; then to the nearby cluster of Samos, Magnesia and Colophon, and the important early centre of Chios. Heading north, we pass Pitane and Lampsacus, and then reach Cyzicus itself. If we glance toward the Black Sea (still part of the same system) we see Heraclia, a strong intellectual centre. Back along the Aegean, Abdera is another important early centre, and then we reach Thasos and Stagira (where we may imagine a young boy developing a passionate interest in all the sciences, before embarking on a pan-Aegean career with Athens as its base). Finally, our tour reaches either Mende or Opus, the home of Philip, Plato's editor. Not much else is left: Cyrene, Elis and a scatter of Italian cities (mainly 'Pythagorean' and thus of poor credentials – with a single great exception, the brilliant Archytas). None of the latter produced more than a single well-authenticated mathematician in this period.

To put it simply, we have made a tour of the Delian league in its widest extent. For most of the period under review, this league has much less political significance. But it is a cultural reality. Here is a string of shores, with a shared experience of the Athenian empire: the Athenian 'commonwealth', let us say. As mentioned above, Athens is often no more than a second home to its intellectuals. It is this area that swells the ranks of Athenian intellectuals. But these are no mere hangers-on in the capital. Chios, Heraclia, Abdera, and of course Cyzicus, show a real local tradition. Autolycus was firmly Pitane-based.¹³³ We cannot say how long Eudoxus really spent in Athens. It does seem that he returned to Cnidus.¹³⁴ This, then, may be emblematic. Athens is the great force of attraction at the centre, but the attraction is limited. Having sojourned in Athens, the mathematician remains attached to his native city. It is easy to speculate on the role of such an 'Athenian period': making contacts, coming to know the latest in the field. The centre of attraction is the great exchange centre. At any rate, regardless of such speculations, two facts stand out. First, the role of the 'Delian area', not just of Athens. Second, the strength of one's native polis. The Greeks of this period are, however itinerant, creatures of their home cities. It is this attachment that makes the wide scatter necessary at this period. And this, of course, was a main source of strength for early Greek intellectual life. The power of the polis prevented the emergence of a single, stifling centre; classical Greek culture was polycentric throughout, however important Athens may have been.

4. Alexandria is Central, Regardless of Political Vicissitudes

The case of Alexandria is different. True, another tour may be made. In fact, the plan of the tour is now even more obvious. Starting at Byzantium (the Black Sea becomes peripheral to a system based on Alexandria), we proceed along the shores of Asia, with a strong concentration in Asia Minor

(taking in a few islands on our way, most of these lying very close to the shores of Asia Minor). There is very little along the more sparsely colonized southern shore of present-day Turkey (it is here, however, that we find the greatest mathematician of our current tour, Apollonius), but the population becomes much denser along the eastern shore of the Mediterranean. It is especially gratifying, for me, to note the strong presence of mathematics (particularly in late antiquity) inside and adjacent to the borders of present-day Israel.¹⁵⁵ Only then do we reach Alexandria. Apart from this tour, we have only Syracuse (which, with Archimedes, would be an exception to any rule); Athens, where mathematics is parasitic upon latter-day Platonism; and a handful of other exceptions (but note that Cyrene is no more than an offshoot of Alexandria).

There are many sites on record. Yet none seems to have had any local tradition, with the possible exception of Nicaea, and the very remote possibility of Pergamon (both, it should be noted, far from Alexandria: local traditions stood a chance only at a very great distance from Alexandria). Spread over 800 years, the various clusters within the scatter lose their meaning. If, instead of a partial map, we could have had a complete animated picture, with lights going on and off across the Mediterranean, signalling the arrival and disappearance of mathematicians, we would have seen a constant light burning at Alexandria, with only a few flickers elsewhere, constantly appearing and disappearing in one place or another, following no clear, individual pattern. Athens was made by the people of the Aegean, but Alexandria made the Mediterranean.

The steadiness of Alexandria is especially remarkable because its political position changed dramatically over those centuries. At first the capital of a thriving Hellenistic kingdom, not set in quickly: from about the end of the third century, Alexandria and the Ptolemaic kingdom declined as political powers, relative to the growing strength of Rome as well as to other, Greek powers.¹⁵⁶ With the final end of the Hellenistic system (30 BC), Alexandria became the capital of a Roman province, always important but never the main seat of power – even when this shifted back to the east with the foundation of Constantinople (324 AD). Through all this, Alexandria kept its centrality. Indeed, the most striking fact is the near absence from our maps of Pella, Antiochia, Rome and Constantinople, all of which overshadowed Alexandria as a political centre except, to a limited extent, during its first century. It is not as if its first century was Alexandria's mathematical hour of glory. Such a view would be based on two mistakes. First, the persistent misdating of Apollonius at not much later than the middle of the third century BC; he belongs in fact to the turn of the century, if not later.¹⁵⁷ Secondly, the importance of Euclid is greatly exaggerated because of the later use of his theories as a textbook. A great systematizer,

Euclid was not a leading mathematician, and in fact he was completely faceless in antiquity. Alexandria did, however, produce at least three central figures in this sequence: Apollonius (200-, in an Hellenistic capital; perhaps one might say a 'declining' Hellenistic capital); Ptolemy (150+, in a provincial capital of a great and thriving empire); and Pappus (300+, in a provincial capital of an empire undergoing a great transformation).¹⁵⁸

Part of the explanation must be very simple. Greek mathematics demands books.¹⁵⁹ Papyri are not enduring. In a Mediterranean across which the lights of mathematics flicker for a moment and then disappear, so would the papyri containing mathematical treatises. In the normal course of events, one's mathematical interests would not survive one's own life-span. No local tradition can develop unless it is already well entrenched, unless during one's own lifetime there is sufficient interest in *reproducing* one's books. This did not happen often. But the accident of a library made all the difference. An ancient library should be understood somewhat like a modern nature reserve. Its point was not only to preserve, but more importantly, to ensure reproduction. Technological developments – first the parchment codex, then print – changed the nature of libraries. The ancient scroll was much more like a living organism, much more in a need of a nature reserve. The miracle was that the Ptolemaic kings had hit upon the idea of setting one up. Here is the real Pharos, shining from Alexandria throughout antiquity.

5. *A Constant Relation between Cultural and Political Centrality?*

What we see, therefore, is a permanent discontinuity between cultural and political centrality. Before Alexandria, the true centre is the periphery – relatively small towns such as Cyzicus. They are strongly related to Athens, but independent from it. In the fourth century, in fact, even the political centrality of Athens is precarious. And, needless to say, its competitors, such powers as Thebes and Sparta, do not provide any intellectual achievement at all.

Later on, Alexandria becomes a centre and remains the centre, regardless of its political fortunes. Rome and Antioch are hardly more important than Sparta or Thebes before them. True, beyond the scope of this article, Constantinople, the capital of the empire, will suddenly flower, with Anthemius, Isidore and other mathematicians. But this is the sixth century AD, when the entire Greek world undergoes its 'Big Crunch', the world collapsing into a single city.

This inverse relationship has been noted by Braudel.¹⁶⁰ Florence, for instance, rather than Venice or Genoa, had set the cultural tone for Italy; English world supremacy coincided with French cultural hegemony. Maps like those provided in this article may give a substantive basis for such

general claims. But, of course, major difficulties of definition and detail emerge. Athens was the ancient Florence, its dialect coming to define Greek, its great authors coming to define good style. True, the canonization took place many years after the political fall of the city, but many of the authors themselves – figures such as Sophocles and Aristophanes – worked in Periclean Athens. Similarly, Latin literature reached an undeniable peak in Augustan Rome. In fact, more recently, Braudel may be accused of a certain chauvinism in his claims for France. The England that won Waterloo also produced Wordsworth. It seems that different intellectual and artistic fields may produce different maps, more or less agreeing among themselves.

As a rule, cultural maps in general will not agree very well with political maps. There is a certain discrepancy between the two kinds of centrality. This has to do partly with differential rates of change, the differential clocks of politics and culture. Political hegemonies may change almost overnight, yet local cultural traditions persist: what is it to Vermeer that Holland lost its naval supremacy? Or, indeed, what is it to Alexandria that Rome is now the world ruler? The pen is slower than the sword.

It is tempting, however, to make a claim even stronger than this; perhaps political centrality is in some ways an impediment to cultural centrality. We may postulate an obvious sociological mechanism: that the Roman aristocrat, for instance, will be much less inclined than his Alexandrian counterpart to lead a life of contemplation. Roman aristocratic patterns compel a life of action. As long as culture was in the hands of the aristocracy, its locus would have been next to, but not precisely at, the focus of political power. At the very centre of power, power was everything. Far away from that centre, no strong aristocracies could be formed. In between, culture could become a substitute for power. Today, on the other hand ... But was culture really removed from the hands of the privileged few?

6. Scale and the Attraction of the Centre

What the two maps have in common – that in both, political and cultural centres differ – is interesting. The dissimilarity is no less interesting. The major feature is the strengthened centrality of Alexandria on the second map. Alexandria seems to have extended a stronger pull than Athens as a mathematical centre. This may seem surprising, since the second map is so much larger. Alexandria's attraction was felt throughout the entire eastern Mediterranean, not just in the Aegean-plus, as was the case of Athens; this with essentially the same technologies of transport and communication. But perhaps scale is in fact the explanation? Over a larger area, communication becomes more difficult. There is more of a need to set up a centre for exchange. No message can be extended to the entire eastern Mediterranean,

unless it is amplified at a centre. This is how Archimedes approached Alexandria, sending letters which obviously were meant to be distributed to correspondents across the Mediterranean.¹⁶¹ And, of course, there is, as mentioned above, the pull of the library. With many more books, the need for the library becomes more acute. In other words, the change of scale is not only geographical, but involves the cultural contents themselves. Greek culture expanded, and, as it did so, required more of a centre to sustain it. It could no longer be recreated time and again in each individual polis. The distinction between centre and periphery thus became sharper.

Archimedes was not the last Sicilian distinguished as the greatest mathematician of his age. Maurolico, active in Sicily around the middle of the sixteenth century, is now recognized as one of the pioneers of modern mathematics. However, his important works were published only posthumously, much too late to have an effect on the development of mathematics at the time. His career reflects a lifetime of failed attempts to gain access to the centres of patronage, manuscripts and print.¹⁶² In the sixteenth century AD, northern Italy was farther away from Sicily than Alexandria had been in the third century BC. The scale of modern culture created an insurmountable divide between centre and periphery. Today, the only path to any cultural achievement passes through the same bottleneck, the same centre of tenured positions, publishing houses, scholarly journals, and, of course, anonymous reviewers.

It may be argued that scale alone cannot explain the difference between Athens and Alexandria. A major shift had occurred, from the civilization of the independent polis to that of the Hellenistic court. Of course, the mode of centrality of Alexandria should therefore be different from that of Athens: the mode of centrality of the entire civilization has similarly changed. I agree, but does not this, at least partly, for the same structural reasons, have to do with scale?

7. Where was Mathematics Scattered?

Returning from such broad structural issues to the maps themselves, let us now look at the actual geographical distribution in 'real', rather than structural terms. The structure is a centre plus a scatter, but where is this scatter?

Something has already been said about this in the context of the Aegean. On the Alexandrian map, there are two interesting points to be noted. First, the complete irrelevance of the ancient Near East to the map. This is related to the well-known question of possible Babylonian influence on Greek mathematics,¹⁶³ as well as to the thesis of Black Athena.¹⁶⁴ But the survey above allows only a limited negative assessment. For one thing, we have almost no clues at all to the ethnic origins of mathematicians. Marinus was a Samaritan, but our evidence for him is exceptional. Many more may have

been Semitic, and certainly some of the Alexandrians may have been of Egyptian origin. But no centre emerges that is not Greek. This is, in a sense, surprising. After all, this is mathematics, not literature. Language is not a factor: Archimedes, for instance, wrote in Doric, and the late mathematical commentators were generally plagued by an awful prose style. Mathematics did not pass through any Atticism, any attempt to cast it in the dominant literary dialect. It was always written in one's native dialect, or in koine, the Hellenistic *lingua franca*. Mathematics does not seem to have other, more specific, cultural connotations. In fact, it has been known in modern times as a bridge between cultures: the role of Jews, and more recently, East Asians, in modern Western mathematics, comes to mind. And, indeed, whatever the relations between Greek and ancient Near Eastern science, there is no question that an important scientific tradition existed in the Near East. Yet Mesopotamia is not even on my maps, and Alexandria was a Greek implant in Egypt.

It seems that ethnicity is not even relevant here. The maps are not ethnic maps. They are, however, cultural maps. What we see is the network of Greek-inspired cities along the Mediterranean, a network imposed on the eastern Mediterranean in the Hellenistic period.¹⁶⁵ Whatever the ethnic make-up of those communities, the structure to which they belonged was defined by a shared Hellenism, transcending regions. And apparently mathematics cannot be divorced from culture as easily as we might think. Mathematics is defined here by the use of proofs. This is a very Greek definition. In a culture in which modes of persuasion are a dominant feature, mathematics comes to be defined by its peculiar form of persuasion. This centrality of the modes of persuasion was fashioned in the Aegean, but remained a part of Greek culture as it spread to the eastern Mediterranean. For a very long period, this remained a peculiar Greek characteristic. Chaldeans went on to produce astronomical tables during our period,¹⁶⁶ but the emergence of a mathematical, demonstrative astronomy was left to authors active in, for example, Nicaea, Rhodes and Alexandria.

It is also remarkable to see how little mathematics penetrated into the western Mediterranean. Apuleius of Madaura is, of course, a product of Athens; Vitruvius and Andron are hardly significant as mathematicians. It is most instructive to look at the gradual disappearance of mathematics from the present-day borders of Italy. Southern Italy had been an exception to the early Aegean concentration of mathematics. This was extinguished forever in the middle of the fourth century BC. Sicily held out a bit longer, to be brutally wiped out with the murder of Archimedes. At close range, the presence of Roman culture was lethal to mathematics. With the fall of Syracuse, a curtain is dropped over the east/west divide; it will only be lifted following the Muslim presence in the western Mediterranean.

This finally brings us to a strikingly long-surviving constant. From early Babylonian mathematics to medieval Muslim mathematics – for three millennia! – the locus of Western mathematics does not change very much. The centres shift from place to place near the eastern shores of the Mediterranean, that is all. Until finally, in the age of the Crusades, the locus shifts almost instantaneously to the belt of universities stretching from northern Italy to England. I have nothing new to say on this amazing revolution; only wishing to stress again how extraordinary it was.

The curtain that fell over the Mediterranean filtered away mathematics, but admitted other aspects of Greek culture. Similarly, the infiltration of mathematics in its Greek form into the eastern Mediterranean was, as explained above, limited to the actual Greek presence. Later on, it did become part of Muslim culture. But there again, the cultural barrier acted as a selective filter, just as in the Roman case. Greek mathematics became a part of Arab culture, yet no Arab poet has ever called his beloved ‘Lesbia’. Geography is important in showing us cultural barriers, but it is even more important to analyze the specific nature of those barriers.

8. Models of Distribution

The final point is not so much a remark as a suggestion for further study. What we saw above is a model of distribution in space and time that may be termed the ‘centre/scatter’ model. There is a centre of attraction, surrounded by a scatter of small, much less significant locations.

It will be interesting to look for other models, in other cases. The most important comparisons are with mathematics in other cultures (Babylonian, for example, or the various models seen in the development of modern science), and with other Greek cultural forms, like philosophy or literature. A few tentative, impressionistic suggestions have been made on such comparisons, but similar in-depth studies are needed.

Further, another type of comparison may be made. Just as it is possible to look at the distribution of individuals in space and time, we may look at the distribution of works in the space of possible positions within a genre. For example, if we produce a catalogue of all known paintings of the Annunciation, we may arrange this catalogue in several ways. We may, for instance, arrange it by time and place of execution (this will be similar in principle to the catalogue offered in this article). Or we may arrange the works according to their stylistic features. We may produce a space of several dimensions, one of which might be, for instance, the distance between the Virgin and the Angel. Another might be the degree of use of rich colours, yet another the degree of use of perspective. And, in such a way, it will be possible to produce a new distribution in space, this time the metaphorical space of positions within a genre.

Hoyrup¹⁶⁷ is a preliminary map of such a distribution, that of Babylonian mathematical treatises within the genre of Babylonian mathematics. The emerging pattern is not a centre/scatter one. Rather, what we see is a number of individual traditions, each with its relatively rigid character. Instead of a central, 'canonical' position, surrounded by positions which are variations on this dominant theme, what we have is a space with a number of centres, a few crossovers, but little between the centres. Instead of the 'centre/scatter' model, this is the 'several centres' model.

So we see two patterns of distribution: the pattern of Greek mathematicians in space, which is a centre/scatter model, and the pattern of Babylonian mathematical treatises in the space of the mathematical genre, which is a several centres model. And, of course, there can be other models. But what I wish to stress now is that it seems that the pattern of Greek mathematical treatises in the space of the mathematical genre is also that of a centre/scatter,¹⁶⁸ and that the pattern of Babylonian mathematicians in space may be that of several centres.¹⁶⁹ In other words, one is tempted to think of the possibility of a certain correlation between the two kinds of patterns. This possibility is, I believe, worth investigation.

NOTES

1. The direct continuation of this article will be a similar catalogue for Arabic mathematics, which I hope to pursue in the future.
2. In some cases, people are associated with more than one city. In such cases, the ordinal number is attached to only one of the cities, and the entry(ies) in the other city(ies) will appear without an ordinal number.
3. *Paulys Realencyclopädie der classischen Altertumswissenschaft*, ed. G. Wissowa *et al.* (Stuttgart, 1904-). This is the standard dictionary for classical studies. Often dated, it still provides the basic classical references and a dependable interpretation. Note that I adopt English-style, latinate transcriptions of the names, instead of the more closely Greek rendering of the Realencyclopädie. The translation from English Greek names to German ones is fairly obvious (e.g. English C becomes German K).
4. Thus, the two maps divide at 300-. My general policy was to indicate 300- individuals on both maps, unless it was clear that they belong only to the Alexandrian system.
5. See especially G.E.R. Lloyd, *Magic, Reason and Experience* (Cambridge, 1979).
6. W. Berkert, *Love and Science in Ancient Pythagoreanism* (Cambridge, MA, 1972).
7. For a further discussion of such questions, see R. Netz, *The Shaping of Deduction in Greek Mathematics: A Study in Cognitive History* (Cambridge, forthcoming), chapter 7.
8. Ibid.
9. I shall note below the one important exception.
10. Netz, *The Shaping of Deduction in Greek Mathematics*.
11. Realencyclopädie V.135.
12. Realencyclopädie III.485.
13. Realencyclopädie II.1065.
14. Realencyclopädie VI.1003.
15. Realencyclopädie VI^a.1258.
16. Realencyclopädie XI.2074.
17. Realencyclopädie V.991.

18. Realencyclopädie VI.358.
19. Realencyclopädie V.1607.
20. Realencyclopädie II.1338.
21. Realencyclopädie II.151.
22. Apollonius' Con. II Intr.
23. Realencyclopädie IV.2849.
24. Realencyclopädie IX.427.
25. Realencyclopädie V.710.
26. Realencyclopädie III^a.1153.
27. Realencyclopädie VI^a. 581.
28. Realencyclopädie VIII.992.
29. Realencyclopädie XV.834.
30. Realencyclopädie XXIII.1788.
31. Realencyclopädie V.1051.
32. Realencyclopädie I.2073.
33. Pappus III. 34.3.
34. Pappus V. Intr.
35. Realencyclopädie XVIII³.1084.
36. Pappus VII. Intr.
37. Realencyclopädie V^a.2075.
38. Realencyclopädie VIII.1080.
39. Realencyclopädie IX.242.
40. Realencyclopädie V.993.
41. Realencyclopädie IV.2849.
42. Realencyclopädie XX.63.
43. Realencyclopädie X.2008.
44. Realencyclopädie II^a. 1677.
45. Serenus 96.14.
46. Realencyclopädie XXII.558.
47. Realencyclopädie I.416.
48. Realencyclopädie IIIa.1157.
49. Realencyclopädie VI.1060.
50. Realencyclopädie XV.1458.
51. Realencyclopädie VIII.1780.
52. Realencyclopädie V^a.1811.
53. Realencyclopädie V^a.1351.
54. Realencyclopädie II.1012.
55. Realencyclopädie IV.2396.
56. Realencyclopädie XV.700.
57. Realencyclopädie XIX.2351.
58. Realencyclopädie IX^a.1512.
59. Realencyclopädie VI.930.
60. Realencyclopädie VIII.472.
61. Realencyclopädie IV.2849.
62. Realencyclopädie VI.895.
63. Diogenes Laertius IV.32.
64. Realencyclopädie II.246.
65. Realencyclopädie XXII.275.
66. Proclus *In Eucl.* 211.16.
67. Realencyclopädie V.1521.
68. Realencyclopädie XX.53.
69. Realencyclopädie XVII.2258.
70. Aristotle, *Meteor.* 343a1.
71. Realencyclopädie VIII.905.
72. Realencyclopädie VI.1363.
73. Realencyclopädie VIII.1687.

74. Pappus Book VII Intr.
75. Realencyclopädie XVII.554.
76. Realencyclopädie II.2025.
77. Aristotle, *Metaph.* 1073b32-38.
78. Realencyclopädie VIII.7.
79. Realencyclopädie XXI.1256.
80. Realencyclopädie XXIII.921.
81. Realencyclopädie I.2895.
82. Realencyclopädie VIII.1706.
83. Realencyclopädie IX^a.427.
84. Realencyclopädie XX.55.
85. Realencyclopädie XVII.463.
86. Realencyclopädie III.927.
87. Realencyclopädie I.2008.
88. Proclus 361.21.
89. Realencyclopädie XXI.1431.
90. Realencyclopädie IV.2054.
91. See Damianus₃.
92. Realencyclopädie VI^a.244.
93. Eutocius in *Arch.* III.258.31.
94. Realencyclopädie V.1005.
95. Realencyclopädie XIV.1759.
96. Realencyclopädie VIII.1666.
97. Realencyclopädie V^a.1930.
98. Sons of Theodosius₅, see S.V.
99. Realencyclopädie IIIa.1879.
100. Iambl. In *Nicom.* 62.18.
101. Apollonius' Book IV Intr.
102. Apollonius I Intr.
103. Realencyclopädie XVI.1954.
104. Realencyclopädie XVII.507.
105. Realencyclopädie II.2602.
106. Realencyclopädie VII.1026.
107. Realencyclopädie I.2159.
108. Realencyclopädie II.873.
109. Realencyclopädie X^a.122.
110. Realencyclopädie V^a.2067.
111. Realencyclopädie II.1055.
112. Realencyclopädie V^a.1811.
113. Realencyclopädie XIX.1918.
114. Realencyclopädie II.507.
115. Archimedes, *Spiral Lines*, Intr.
116. Vitruvius I.17.
117. Realencyclopädie II.600.
118. Proclus 66.15.
119. Realencyclopädie XX.55.
120. *Elements* XIV Intr.
121. Proclus 66.19.
122. Proclus 66.18.
123. Realencyclopädie I.2529.
124. Archimedes II. 216.18.
125. Realencyclopädie VI^a.577.
126. Realencyclopädie X^a.18.
127. Realencyclopädie III.2173.
128. Realencyclopädie XVII.500.
129. Realencyclopädie V.813 (The date offered follows G.J. Toomer, *On Burning*

Mirrors/Diocles (New York, 1976), pp.9–15.

130. Realencyclopädie XI.679.
131. Realencyclopädie IV.2849.
132. Realencyclopädie VIII.1080.
133. Eutocius, *In Archim.* III 120.8.
134. Diogenes Laertius IV.23.
135. Pappus III. 106.6–9.
136. Pappus VII. 128–129 (=1077).
137. Proclus 272.7.
138. *Anth. Gr.* ix.200.
139. Pappus VII. 640.25.
140. Realencyclopädie XIX.1021.
141. Eutocius *in Arch.* 56.13.
142. *Anth. Gr.* ix.200.
143. Note that several of our names derive from Proclus' famous summary of the early history of the Elements, *in Euclid* 66–7. The main interest there is clearly in relating the history of the Elements to Proclus' philosophical heroes, and especially to Plato. It is such interests which shape our evidence.
144. Especially the third century BC, which we know to have been the period of greatest qualitative expansion.
145. The low numbers – and the low quality of work they represent – at about the turn of the millennia, are striking indeed. It seems reasonable to suppose that the final subjugation of the east, from Sulla's Mithridatic campaigns to the aftermath of Actium, was so extreme in its cruelty as to have far-reaching repercussions on intellectual life as well. See, for instance, J. Glucker, *Antiochus and the Late Academy* (Göttingen, 1978) especially pp.364 ff., on the fate of philosophical schools at this period.
146. Diogenes Laertius IV.29.
147. Mathematical life expectancy is an important demographic question: for how many years would a person be active as a mathematician? Given that they were not tenured academics, but simply people who found mathematics interesting, I suspect the average mathematical life expectancy was in fact much below 20 years (which is the number implicit in the crude calculation this note refers to). An Archimedes would devote his whole life, except in time of war, to mathematics, but for most others this would have been another pastime among many, to be taken up briefly.
148. The source is Epicurus On Nature XI. See D.N. Sedley, 'Epicurus and the Mathematics of Cyzicus', *Cronache Ercolanesi*, 6 (1976), pp.23–54.
149. A useful indication of the mobility of Greek mathematicians is the list of astronomical observations used by Ptolemy (O. Pedersen, *A Survey of the Almagest* (Odense, 1974), appendix A). There, the same astronomer is often recorded as having made observations in more than a single location.
150. Apollonius could have left Perga as a child, of course. But the possibility remains that he came to Alexandria *because* he was a mathematician, not in order to become one.
151. We learn this from Philoponus (a sixth century AD author), in the course of a commentary on Aristotle (*In Phys.* 31, 3). Earlier sources have Hippocrates as only a Chian.
152. Plato, *Theaetetus*, 143d.
153. See n. 105 above.
154. Diogenes Laertius VIII.88.
155. Note also that Eutocius of Ascalon is outside my time frame; but he belongs to the same area and period.
156. See P.M. Fraser, *Ptolemaic Alexandria* (Oxford, 1972), chapter 3, esp. pp.75 ff.
157. See G.J. Toomer, 'Apollonius', in C.C. Gillespie (ed. in chief), *Dictionary of Scientific Biography* (New York, 1970).
158. It is true, however, that Alexandria remained throughout a major port, a large and on the whole a prosperous city. Its vicissitudes were political, not so much economic.
159. This is argued in Netz, op. cit.
160. F. Braudel, *The Perspective of the World* (London, 1984), pp.67–9.

161. See especially the introduction to the *Sphere and the Cylinder*, Book I, where Archimedes effectively states that, having lost his one mathematical correspondent, Conon, he has to approach whomever he can find in Alexandria, so that his work may reach other mathematicians.
162. P.L. Rose, *The Italian Renaissance of Mathematics* (Geneva, 1975), chapter 8.
163. See J. Hoyrup, 'Algebra and Naïve Geometry: an Investigation of Some Basic Aspects of Old Babylonian Mathematical Thought', *Altorientalische Forschungen*, 17 (1990), pp.27–69, 262–354; and 'Dynamis, the Babylonians and Theaetetus', pp.147c7–148d7, *Historia Mathematica*, 17 (1990), pp.201–22; for a powerful statement of the case for Babylonian influence. I am sceptical myself, especially in view of my basic claim that mathematics had never more than the most precarious hold on the Mediterranean. No safe channels of communication, sustained for long periods, can be imagined, certainly not in the pre-history of Greek mathematics.
164. M. Bernal, *Black Athena: The Afroasiatic Roots of Classical Civilization* (London, 1987).
165. Many extant works by Greek mathematicians are preceded by brief introductions, in which the work is addressed to a fellow mathematician. In most cases, the dedicatee comes from another city. Archimedes, for instance, dedicated some of his works to individuals in Samos (Conon), Pelusion (Dositheus) and Alexandria (Eratosthenes). Such dedications give an indication of the 'network' referred to.
166. See O. Neugebauer, *Mathematical Cuneiform Texts* (New Haven, 1945), pp.351–2 for the dates of the sources of Babylonian astronomy: roughly 600- to 50+, but concentrated in the last three centuries BC.
167. J. Hoyrup, *The Finer Structure of the Old Babylonian Mathematical Corpus* (Filosofi og Videskabsteori på Roskilde Universitetscenter 3. Række: Preprints og Reprints 1996 nr. 4).
168. See Netz, *The Shaping of Deduction in Greek Mathematics*.
169. See Neugebauer, *Mathematical Cuneiform Texts*, Vol. I, pp.13 ff.