THALES

THE Greeks attributed to Thales a great many discoveries and achievements. Few, if any, of these can be said to rest on thoroughly reliable testimony, most of them being the ascriptions of commentators and compilers who lived anything from 700 to 1,000 years after his death—a period of time equivalent to that between William the Conqueror and the present day. Inevitably there also accumulated round the name of Thales, as round that of Pythagoras (the two being often confused[1]), a number of anecdotes of varying degrees of plausibility and of no historical worth whatsoever. These and the achievements credited to Thales have, of course, been painstakingly brought together by Hermann Diels in *Der Fragmente der Vorsokratiker*.[2] Useful and necessary (though not entirely comprehensive[3]) as this work undoubtedly is, it nevertheless has probably contributed as much as any other book to the exaggerated and false view of Thales which we meet in so many modern histories of science or philosophy, and which it is the purpose of this article to combat. In Diels, quotations from sources such as Proclus, Aëtius, Eusebius, Plutarch, Josephus, Iamblichus, Diogenes Laertius, Theon Smyrnaeus, Apuleius, Clemens Alexandrinus, and Pliny, of different dates and varying reliability, are listed indiscriminately side by side with a few from Herodotus, Plato, and Aristotle, in order to provide material for a biography of Thales; but so uncertain is this material that there is no agreement among the 'authorities' even on the most fundamental facts of his life—e.g. whether he was a Milesian or a Phoenician, whether he left any writings or not, whether he was married or single—much less on the actual ideas and achievements with which he is credited. The critical evaluation of the worth of these citations is left entirely to the reader. Future historians of classical antiquity who (in the not improbable event of a general cataclysm) may have to rely entirely on secondary sources such as Diels are likely to form an extremely erroneous idea of the validity and completeness of our knowledge of Thales.

It is worth while examining the material in Diels a little more closely. Very broadly, the sources may be classified in two main divisions, namely, writers before 320 B.C. (Thales' *floruit* is usually and probably correctly given as the first quarter of the 6th century B.C.) and those after this date—some being nearly a millennium after it, e.g. Proclus (5th century A.D.) and Simplicius (6th century A.D.). In the first division there are only three writers in Diels's list who mention Thales, viz. Herodotus (Diels 4, 5, and 6—the references are to the numbered quotations in Diels's section on Thales, which are discussed here in numerical order), Plato (Diels 9; also *Rep.* 10. 600a—cf. Diels 3), and Aristotle (Diels 10, 12, and 14). What do they tell us about him? Herodotus, who calls him a Milesian of Phoenician descent, mentions with approval his

[1] e.g. the well-known story of the sacrifice of an ox on the occasion of the discovery that the angle on a diameter of a circle is a right angle is told about both Thales and Pythagoras (Diog. Laert. 1. 24–25); cf. Schwartz in *P.W.* s.v. 'Diogenes Laertios', col. 741; Pfeiffer, *Callimachus*, 1949, i. 168.

[2] 8th ed. 1956, edited by W. Kranz.

[3] There are in classical literature at least three mentions of Thales not included by Diels, viz. Aristophanes, *Clouds* 180; *Birds* 1009; Plautus, *Captivi* 274; and there are probably more. Cf. O. Gigon, *Der Ursprung der griechischen Philosophie*, 1945, p. 11, for a plea for a really complete collection of notices regarding the Pre-Socratics.

recommendation to the Ionians to form a federation with one paramount assembly in Teos (I. 170 = Diels 4). Relying on this notice and the inclusion of Thales among the Seven Wise Men, Gigon[1] suggests that Thales' 'book' (if he ever wrote one—see below) contained political material. Then comes the much discussed passage (I. 74 = Diels 5) about Thales' prediction of a solar eclipse—Herodotus' actual words are: *τὴν δὲ μεταλλαγὴν ταύτην τῆς ἡμέρης Θαλῆς ὁ Μιλήσιος τοῖσι Ἴωσι προηγόρευσε ἔσεσθαι, οὖρον προθέμενος ἐνιαυτὸν τοῦτον, ἐν τῷ δὴ καὶ ἐγένετο ἡ μεταβολή.* The eclipse is generally regarded as being that of 28 May 585 B.C.,[2] and Thales is supposed to have predicted it by means of the old lunar cycle of 18 years and 11 days, i.e. 223 lunar months, in which both solar and lunar eclipses may repeat themselves in roughly the same positions. Much has been made of this cycle, often (but quite erroneously[3]) called the 'Saros', which Thales is supposed to have borrowed from the Babylonians;[4] modern historians of science have eagerly seized on it as evidence for the traditional picture of Thales as the intermediary between the wisdom of the East and Greece, so that now it figures prominently in practically every account of Thales. The Babylonians, however, did not use cycles to predict solar eclipses, but computed them from observations of the latitude of the moon made shortly before the expected syzygy.[5] Moreover, as Neugebauer says: 'There exists no cycle for solar eclipses visible at a given place; all modern cycles concern the earth as a whole. No Babylonian theory for predicting a solar eclipse existed at 600 B.C., as one can see from the very unsatisfactory situation 400 years later; nor did the Babylonians ever develop any theory which took the influence of geographical latitude into account.'[6] Yet the manner in which Herodotus reports the prediction, *οὖρον προθέμενος ἐνιαυτὸν τοῦτον*,[7] would lead one to suppose that Thales did make use of a cycle. It is perhaps just possible that he may have heard of the 18-year cycle for lunar phenomena, and may have connected it with the solar eclipse of 585 in such a way as to give rise to the story that he predicted it; if so, the fulfilment of the 'prediction' was a stroke of pure luck and not science, since he had no conception of geographical latitude and no means of knowing whether a solar eclipse would be visible in a particular locality. It is difficult to see what the remark, allegedly quoted from Eudemus by Dercyllides,[8] to the effect that 'Thales was the first to discover an eclipse of the sun' (... *εὗρε πρῶτος* ... *ἡλίου ἔκλειψιν*),

[1] O. Gigon, *Der Ursprung der griechischen Philosophie*, 1945, p. 42.

[2] Cf. Boll in *P.W.* s.v. 'Finsternisse', col. 2353; Heath, *Aristarchus of Samos*, 1913, pp. 13–16; Fotheringham in *J.H.S.* xxxix [1919], 180 ff., and in *M.N.R.A.S.* lxxxi [1920], 108.

[3] Cf. O. Neugebauer, *The Exact Sciences in Antiquity*, 2nd ed. 1957, pp. 141–2.

[4] Ptolemy mentions it (*Synt. math.*, ed. Heiberg, i. 269. 18 f.) and also the *ἐξελιγμός*, a similar cycle obtained by multiplying the former by 3, making 669 lunar months or 19,756 days, but attributes both to *οἱ ἔτι παλαιότεροι μαθηματικοί*, which refers to Greek astronomers earlier than Hipparchus and not to the Babylonian astronomers, whom Ptolemy always calls *οἱ Χαλδαϊκοί*.

[5] F. X. Kugler, *Sternkunde und Sterndienst in Babel*, ii (1909), 58 f.; O. Neugebauer, *Astronomical Cuneiform Texts*, i (1956), 68–69, 115, 160 f.

[6] *Ex. Sci.*, p. 142. As regards the use of the 18-year cycle he says (ibid.), 'there are certain indications that the periodic recurrence of *lunar* eclipses was utilised in the preceding period [i.e. before 311 B.C.] by means of a crude 18-year cycle which was also used for other lunar phenomena' (my italics).

[7] Diels's suggestion (*Antike Technik*, 3rd ed. 1924, p. 3, n. 1) that *ἐνιαυτός* here means 'solstice' has nothing to recommend it.

[8] *Ap.* Theon. Smyrn., p. 198. 14, ed. Hiller = Diels 17.

actually means. It can hardly mean that he was the first to *notice* a solar eclipse; but if it means that he was the first to discover the cause of one, then it is certainly wrong, for he could not possibly have possessed this knowledge which neither the Egyptians nor the Babylonians nor his immediate successors possessed.[1] In fact the report is an obvious amplification of Herodotus' story with a further discovery attributed to Thales (that he also found the cycle of the sun with relation to the solstices) thrown in for good measure, merely because it seemed plausible to Eudemus or Dercyllides. After Herodotus,[2] the doxographical writers and Latin authors like Cicero and Pliny (cf. Diels 5) go on repeating the story with or without further embellishment, but it is perhaps significant that no other writer in the first group of sources (i.e. those before 320 B.C.) mentions it. Of modern commentators, Martin[3] long ago rejected the entire story, Dreyer[4] is extremely sceptical, and Neugebauer,[5] the most recent authority, also refuses to credit it.

Next in Diels's collection is Herodotus' story (1. 75 = Diels 6) of Thales' reputed diversion of the river Halys to enable King Croesus to invade Cappadocia—a story, be it noted, which Herodotus reports as being generally believed among the Greeks, but which he himself explicitly refuses to accept.[6] Then Plato (*Rep.* 10. 600a), in a discussion of the desirability of tolerating Homer in the ideal state, takes Thales as an example of the clever technician, ἀλλ' οἷα δὴ εἰς τὰ ἔργα σοφοῦ ἀνδρὸς πολλαὶ ἐπίνοιαι καὶ εὐμήχανοι εἰς τέχνας ἤ τινας ἄλλας πράξεις λέγονται, ὥσπερ αὖ Θαλέω τε περὶ τοῦ Μιλησίου καὶ Ἀναχάρσιος τοῦ Σκύθου.[7] Elsewhere (*Theaet.* 174a = Diels 9) he is cited as an example of the absent-minded star-gazer who is so intent on the heavens that he does not see what is at his feet and falls into a well.[8] Aristotle (*Pol.* A, $1259^{a}5$ = Diels 10) tells the story of Thales' foresight and business acumen in buying up all the olive-presses in Miletus and Chios during one winter, in anticipation of a bumper olive crop later; when this duly materialized he was able to hire them out at great profit to himself.

Finally, in this first group of sources, Thales' philosophical speculations are limited to two main propositions only, each accompanied by a more or less fanciful corollary, viz. (1) that water is the primary substance of the universe (Diels 12), and that the world rests on water (Diels 14), and (2) that everything is full of gods πάντα πλήρη θεῶν (Diels 22), and that the lodestone has a soul (ibid.). It is worth noting the manner in which Aristotle reports these speculations; as regards (1), which seems to be the most definite, Aristotle

[1] Cf. G. S. Kirk and J. E. Raven, *The Presocratic Philosophers*, 1957, p. 78—Kirk's reference to 'the undoubted fact of Thales' prediction' is a considerable overstatement.

[2] Gigon (op. cit., p. 52) thinks that Herodotus may have taken the story from a poem of Xenophanes, who perhaps expressed incredulity at the report; but it seems much more probable that Herodotus is relating the generally accepted hearsay of his time.

[3] *Revue Archéologique*, ix [1864], 170–99.

[4] J. L. E. Dreyer, *A History of Astronomy* (originally entitled *A History of the Planetary Systems*), repr. 1953 (Dover Publications, New York), p. 12.

[5] *Ex. Sci.*, p. 142. Neugebauer complains of the vagueness of Herodotus' report, but this is somewhat unjust; obviously, what impressed Herodotus was the sudden change from bright daylight to comparative darkness—hence the choice of the words μεταλλαγή and μεταβολή.

[6] ὡς μὲν ἐγὼ λέγω, κατὰ τὰς ἐούσας γεφύρας διεβίβασε τὸν στρατόν, ὡς δὲ ὁ πολλὸς λόγος τῶν Ἑλλήνων, Θαλῆς οἱ ὁ Μιλήσιος διεβίβασε. Kirk and Raven (op. cit., p. 76) cite this as 'convincing evidence' for Thales' reputation as an engineer—the adjective seems hardly appropriate.

[7] On this and the scholion (= Diels 3), see below.

[8] This earliest example of a perennially

says, Θαλῆς μὲν ὁ τῆς τοιαύτης ἀρχηγὸς φιλοσοφίας ὕδωρ φησὶν εἶναι (διὸ καὶ τὴν γῆν ἐφ' ὕδατος ἀπεφήνατο εἶναι), λαβὼν ἴσως τὴν ὑπόληψιν ταύτην ἐκ κ.τ.λ., and in another place (*de caelo* B 13. 294^{a}28) τοῦτον γὰρ [τὴν γῆν ἐφ' ὕδατος κεῖσθαι] ἀρχαιότατον παρειλήφαμεν τὸν λόγον, ὅν φασιν εἰπεῖν Θαλῆν τὸν Μιλήσιον: as regards (2) Aristotle's words are (*de anima* A, 411^{a}8), ὅθεν ἴσως καὶ Θαλῆς ᾠήθη πάντα πλήρη θεῶν εἶναι, while elsewhere he is even more hesitant (*de an.* A, 405^{a}19), ἔοικε δὲ καὶ Θαλῆς ἐξ ὧν ἀπομνημονεύουσι κινητικόν τι τὴν ψυχὴν ὑπολαβεῖν, εἴπερ τὴν λίθον ἔφη ψυχὴν ἔχειν, ὅτι τὸν σίδηρον κινεῖ. Snell, in an article which examines critically the process of transmission of Thales' philosophical opinions,[1] notes that the first quotation (*Metaph.* I. 3. 983^{b}21 = Diels 12) gives a false impression of definiteness on Aristotle's part, because the passage continues (984^{a}1) εἰ μὲν οὖν ἀρχαία τις αὕτη καὶ παλαιὰ τετύχηκεν οὖσα περὶ τῆς φύσεως ἡ δόξα, τάχ' ἂν ἄδηλον εἴη, Θαλῆς μέντοι λέγεται οὕτως ἀποφήνασθαι περὶ τῆς πρώτης αἰτίας, and Diels ought certainly to have continued the quotation as far as this.[2] In several other instances Snell corrects what appear in Diels as philosophical speculations attributed by Aëtius to Thales, and shows that in reality these stem directly from Aristotle's own interpretations which then became incorporated in the doxographical tradition as erroneous ascriptions to Thales[3]—and, one might add, are duly perpetuated by Diels–Kranz.

So much, then, for what may be termed the primary authorities for our knowledge of Thales' life and opinions, e.g. writers before 320 B.C. What is the general impression we obtain from them? Surely, that he had a reputation chiefly as a *practical* man of affairs, who was capable of giving sensible political advice (his recommendation to the Ionians to unite), was astute in business matters (the transaction with the olive-presses), and had an inquiring turn of mind with a bent towards natural science and the ability to put to practical use whatever knowledge he possessed (the stories of the eclipse prediction and the diversion of the river Halys). This picture of Thales is amply substantiated by the other references to him in classical writers not listed in Diels, e.g. Aristophanes, *Clouds* 180; *Birds* 1009; Plautus, *Captivi* 274—in each of these passages he is cited as the typical example of the clever man (perhaps not always scrupulous in his methods? *Clouds* 180—cf. the story of the olive-presses) noted as much for his resourcefulness as for his sagacity. The single discordant note is Plato's story of his falling into a well, but then this is the kind of anecdote which might be told about anyone interested in astronomy, and is by no means an indication of habitual absent-mindedness on Thales' part. It is not surprising that a man endowed with the qualities enumerated above should in due course be numbered among the Seven Wise Men of Greece. There was

popular genre of comic story has been subjected to a solemn discussion and analysis by M. Landmann and J. O. Fleckenstein, 'Tagesbeobachtung von Sterner in Altertum', *Vierteljahrschr. d. Naturf. Gesch. in Zürich*, lxxxviii [1943], 98 f., in the course of which it is suggested that the story is not 'echt oder unecht', but contains a germ of historical truth in that Thales probably observed stars in daylight from the bottom of a well! The article contains an entirely uncritical account of Thales' alleged achievements and discoveries, with the usual imaginary picture of him as the transmitter of Egyptian and Babylonian wisdom.

[1] B. Snell, 'Die Nachrichten über die Lehren des Thales und die Anfänge der griechischen Philosophie- und Literaturgeschichte', *Philologus* xcvi (1944), 170–82.

[2] Id., op. cit., p. 172.

[3] Op. cit. pp. 170 and 171 with footnote (1). Thales, of course, was not the only early thinker to be thus treated by Aristotle; Anaxagoras was another—cf. F. M. Cornford, 'Anaxagoras' Theory of Matter—II', *C.Q.* xxiv [1930], 83–95.

never complete agreement among the ancient writers on the names of the Seven or even on the number itself,[1] but four names occur regularly in the various lists given—Thales, Solon, Bias, and Pittacus; and these, be it noted, were all essentially *practical* men who played leading roles in the affairs of their respective states, and were far better known to the earlier Greeks as lawgivers and statesmen than as profound thinkers and philosophers.[2] As we shall see, it is only from the second group of sources, i.e. writers after 320 B.C., that we obtain the picture of Thales as the pioneer in Greek scientific thinking, particularly in regard to mathematics and astronomy which he is supposed to have learnt about in Babylonia and Egypt. In the earlier tradition he is a favourite example of the intelligent man who possesses some technical 'know-how'.[3]

One very important point that can be established from consideration of this first group of sources is that no written work by Thales was available for consultation to either Herodotus, Plato, or Aristotle—the tradition about him, even as early as the fifth century B.C., was evidently based entirely on hearsay. This seems quite certain; for all mentions of him are introduced by words such as φασί, λέγεται, ᾠήθη, ἔοικε, and the like, and never[4] is a citation given that reads as though taken directly from a work by Thales himself. This fact has obvious implications for our judgement of the trustworthiness of the information that later writers give us about him. It is even doubtful whether he ever produced any written work at all;[5] certainly there was a persistent tradition in later antiquity that he left none.[6] It would seem that already by Aristotle's time the early Ionians were largely names only[7] to which popular tradition attached various ideas or achievements with greater or less plausibility;

[1] See Diog. Laert., I. 40 f.

[2] Werner Jaeger, *Aristotle*, 2nd ed. 1948 (translated into English by R. Robinson), Appendix II, 'On the Origin and Cycle of the Philosophic Life', p. 454, is surely wrong in saying that the reports emphasizing the practical and political activities of the Seven Wise Men were first introduced into the tradition by Dicaearchus in the latter half of the fourth century. In the case of Thales, at any rate, it is the *early* tradition as exemplified by Herodotus that makes him a practical statesman, while the later doxographers foist on to him any number of discoveries and achievements, in order to build him up as a figure of superhuman wisdom. Jaeger is also wrong in asserting that Plato had made Thales 'a pure representative of the theoretical life' (op. cit., p. 453)—he apparently overlooks *Rep.* 10. 600a, where this is far from being the case, and he takes the well story too seriously. On the other hand, he is undoubtedly right to emphasize the comparatively late origin of the traditional picture of Pre-Socratic philosophy, 'the whole picture that has come down to us of the history of early philosophy was fashioned during the two or three generations from Plato to the immediate pupils of Aristotle' (429).

[3] See especially Plato, *Rep.* 10. 600a (and Burnet, *Early Greek Philosophy*, p. 47 n. 1) where Thales is coupled with Anacharsis, who is said to have invented the potter's wheel and the anchor.

[4] The single apparent exception (*Met.* I. 3. 983^{b}21 = Diels 12), where Aristotle seems to be more definite, has already been shown to be illusory, in that if the quotation were carried to its proper end we should find the familiar Θαλῆς λέγεται again. Kirk and Raven (op. cit., p. 85) also remark on the cautious manner in which Aristotle cites Thales; cf. Snell, op. cit., pp. 172 and 177—but Snell's insistence that Aristotle is not relying merely on oral tradition but must be using a pre-Platonic written source (which Snell identifies as Hippias) is hardly convincing on the evidence available.

[5] What Diels (pp. 80–81) prints as 'Angebliche Fragmente' of Thales' works are, of course, completely spurious, as Diels himself points out.

[6] Diog. Laert. I. 23, καὶ κατά τινας μὲν σύγγραμμα κατέλιπεν οὐδέν: cf. Joseph. *c.Ap.* I. 2; Simplicius, *Phys.* 23. 29.

[7] Cf. Kirk and Raven, p. 218—Aristotle, Plato, and Pythagoras.

naturally this process gave rise to numerous permutations and combinations of the names and the attributes among the later writers of our second group of sources. Even the works of men like Anaximander and Xenophanes, the existence of whose writings in the sixth century B.C. anyway is unquestioned, by the fourth century B.C. either had disappeared completely or were extant in one or two scattered copies distinguished by their rarity;[1] and if this was the situation in the time of Aristotle, it can confidently be said that the chances that the original works of the earlier Pre-Socratics were still readily available to his pupils, such as Theophrastus and Eudemus, much less to their excerptors and imitators in succeeding centuries, are extremely small. Nearly always when a later commentator attributes some idea to Thales or any other early Ionian the ascription is based not on the original work, nor even on some other writer's citation of the original, but on some 'authority' two, three, four, five, or more stages removed from the original (see below).

It is when we come to the second main group of sources, i.e. writers after 320 B.C., that Thales' stature begins to take on heroic proportions and he appears as the figure so dear to modern historians of science and philosophy—the founder of Greek mathematics and astronomy, the transmitter of ancient Egyptian and Babylonian wisdom, the first man to subject the empirical knowledge of the orient to the rigorously analytic Greek method of reasoning; and, of course, the later the 'authority' the more freely does he ascribe all sorts of knowledge to Thales.[2] It is again to Hermann Diels that we are indebted for a detailed examination of these later sources. His large volume, *Doxographi Graeci*, which first appeared in 1879 and achieved a second edition in 1929, remains the standard work on the subject. Diels's results are by now well known.[3] In 263 pages of Prolegomena he gives a detailed, critical discussion of the doxographical writers from Theophrastus (4th–3rd centuries B.C.) to Tzetzes (12th century A.D.), analyses the probable sources of each writer's information, and traces with patient ingenuity the interconnexions and ramifications of these sources among the host of epitomators, excerptors, and compilers who flourished in later antiquity. Briefly, one of the main results of Diels's work is the re-emergence of Aëtius, an eclectic of the first or second centuries A.D.,[4] whose lost *Συναγωγὴ τῶν ἀρεσκόντων* is shown to be largely preserved in the pseudo-Plutarchean *Placita Philosophorum* and in the *'Εκλογαί* of Stobaeus.[5] All such collections of *ἀρέσκοντα* or placita are derived ultimately from the *Φυσικῶν δόξαι* of Theophrastus who, following the example initiated by Aristotle (e.g. at the beginning of the *Metaphysics*), set out to record the opinions of the early thinkers on various problems of philosophy and natural science; but Diels shows that our extant sources, far from taking their material directly from Theophrastus' work, preferred to use one or more intermediaries, so that what we actually read in them comes to us not even at second, but at third or fourth or fifth hand. Thus Aëtius did not use Theophrastus directly, but (with additions from other sources) an epitome of him which Diels calls

[1] Cf. Diels, *Dox.* p. 219; p. 112.

[2] Oddly enough, this tendency can also be seen in modern times. Earlier writers, like Tannery, are far less prone to exaggerate Thales' achievements than more recent ones, such as van der Waerden—on whom see further below.

[3] There are summaries in Zeller, *Outlines of the History of Greek Philosophy*, 13th ed. repr. 1948, pp. 4–8; Burnet, *Early Greek Philosophy*, 4th ed. repr. 1952, pp. 33–38; Kirk and Raven, op. cit., pp. 1–7; cf. P.-H. Michel, *De Pythagore à Euclide*, 1950, pp. 72–167—a useful reference section for all the sources relevant to Greek mathematics.

[4] *Dox.*, p. 101.

[5] *Dox.*, pp. 45 f.

the *Vetusta Placita*[1] and which seems to have appeared towards the end of the second century B.C., possibly in the school of Posidonius. Obviously this use of intermediate sources, copied and recopied from century to century, with each writer adding additional pieces of information of greater or less plausibility from his own knowledge, provided a fertile field for errors in transmission, wrong ascriptions, and fictitious attributions—as can be seen, for example, in the scrap-book of Diogenes Laertius.[2] Aëtius himself is by no means always a reliable source; Snell[3] has shown how two passages, which in Diels–Kranz are accepted as genuine opinions of Thales, are in fact merely Aëtius' interpretations of remarks by Aristotle which have nothing to do with Thales. Similarly, Aëtius' coupling of Thales and Pythagoras (!) in connexion with the division of the celestial sphere into five zones is entirely erroneous, as the theory of zones (i.e. the bands of the globe bounded by the 'arctic', 'antarctic', equator, and tropics) can hardly have been formulated before the time of Eudoxus.[4]

Now if Theophrastus himself was in error on any point either through misinterpretation or lack of reliable information (which we have not the slightest reason to doubt was frequently the case as regards the Pre-Socratics[5]), it is perfectly obvious that there is no chance at all that his later copyists and excerptors would either recognize or be in a position to correct the error. We have seen already that even if Thales did write a book it was no longer extant in Aristotle's time. This being the case, it can be taken for granted that no copy was available to Theophrastus either. Hence all that he knew about Thales was what he could gather from Aristotle's previous mentions of him, supplemented perhaps by a few more scraps of information gained from hearsay.[6] We have seen the type of information that Aristotle possessed, and this, it should be remembered, was the direct, authentic line of the tradition. Yet modern commentators persist in ascribing as much, if not more, weight to the exaggerated stories of Thales' achievements given by post-Theophrastean writers who had to rely on their own imaginations to bolster the meagre account that was all that Aristotle or Theophrastus could give. It needs to be borne in mind that the preservation of old texts and the careful referring back to the *ipsissima verba* of the author are comparatively modern innovations of scholarship, which, though seeming to us of fundamental importance, were by no means so regarded by the ancients. Cicero makes a revealing remark in this connexion: talking about Aristotle's work on the early handbooks of rhetoric, he says 'ac tantum inventoribus ipsis suavitate et brevitate dicendi praestitit ut nemo illorum praecepta ex ipsorum [i.e. veterum scriptorum] libris cognoscat, sed omnes qui quod illi praecipiant velint intellegere ad hunc quasi ad quendam multo commodiorem explicatorem revertantur'.[7] Exactly the same holds true for the early philosophers; if one wanted to know their opinions, one consulted Theophrastus or Eudemus (on whom see more below) or

[1] *Dox.*, pp. 179 f.

[2] Cf. Schwartz in *P.W.* s.v. 'Diogenes Laertios'; *Dox.*, pp. 161 f.

[3] Op. cit., pp. 170–1, 176.

[4] Cf. J. O. Thomson, *History of Ancient Geography*, 1948, pp. 112 and 116.

[5] Cf. G. S. Kirk, *Heraclitus: the Cosmic Fragments*, 1954, pp. 20–25.

[6] What Gigon (op. cit., pp. 43–44) calls the 'anekdotische und apophthegmatische Überlieferung'.

[7] *De invent.* 2. 2. 6. Further on he mentions Isocrates whose book Cicero knows to exist but which he has not himself found, although he has come across numerous writings by Isocrates' pupils.

Menon[1]—one would not bother to go back to the original works even in the unlikely event of their being still available.[2] There is, therefore, no justification whatsoever for supposing that very late commentators, such as Proclus (5th century A.D.) and Simplicius (6th century A.D.), can possibly possess more authentic information about the Pre-Socratics than the earlier epitomators and excerptors who took their accounts from the above disciples of the Peripatetic School, who in turn depended mainly on Aristotle himself and perhaps to a small extent on an oral tradition such as obviously forms the basis of Herodotus' stories about Thales.

Diels,[3] in a comparative examination of four later works which depend ultimately on Theophrastus, viz. Hippolytus' *Philosophoumena*, pseudo-Plutarch's *Stromata*, Diogenes Laertius, and Aëtius (the 'biographical doxographers' as Burnet calls them[4]), shows that in each case two primary sources can be traced, (*a*) a 'futtilissimum Vitarum compendium', a very inferior compilation based on biographical material of dubious authenticity gleaned from the same sources as were presumably used by Aristoxenus and the later writers of 'Successions' (*Διαδοχαί*) such as Sotion—this must represent the pre-literary oral tradition of popular hearsay; and (*b*) a good epitome of Theophrastus by some unknown writer. It is particularly noteworthy that the notices regarding Thales, Pythagoras, Heraclitus, and Empedocles are entirely derived from the first inferior source—yet another indication of the paucity of genuine knowledge about these early figures. One result of this lack of information was that very soon certain doctrines that later commentators invented for Thales, and that became fixed in the doxographical tradition, were then accepted into the biographical tradition, and thus, because they may be repeated by different authors relying on different sources, may produce an illusory impression of genuineness. This can be shown to have happened in the case of the dogma *ὁ κόσμος ἔμψυχος*, which in reality stemmed from Aristotle and not from Thales, but which reappears in the biographical tradition that underlies both the scholion on Plato, *Rep.* 10. 600a and Diogenes Laertius 1. 27.[5]

I must now discuss the source on which modern scholars[6] rely most of all to substantiate their exaggerated views of Thales' knowledge and achievements—namely, Eudemus, who to some extent bridges the gap between what I have called the primary and secondary sources for our knowledge of Thales. It is generally considered that it is from Eudemus' *Γεωμετρικὴ ἱστορία*, *Ἀριθμητικὴ ἱστορία*, and *Ἀστρολογικὴ ἱστορία*[7] that all later writers derive their information

[1] Cf. Jaeger, *Aristotle*, p. 335; in the work of compiling a comprehensive history of human knowledge Menon was allotted the field of medicine, Eudemus that of mathematics and astronomy and perhaps theology, and Theophrastus that of physics and metaphysics.

[2] Cf. Diels, *Dox.*, p. 128.

[3] *Dox.*, pp. 145 f.

[4] *Early Greek Philos.*, p. 36.

[5] Snell, op. cit., pp. 175–6.

[6] Such as, F. Cajori, *A History of Mathematics*, 1919, pp. 15 f.; D. E. Smith, *History of Mathematics*, i (1923), 64 f.; G. Sarton, *Introduction to the History of Science*, repr. 1950, i. 72; W. Capelle, *Die Vorsokratiker*, 4th ed. 1953, pp. 67 f.; B. L. van der Waerden, *Science Awakening*, 1954, pp. 86 f.; G. Hauser, *Geometrie der Griechen von Thales bis Euklid*, 1955, pp. 43–49; Gomperz, *Greek Thinkers*, repr. 1955, i. 46–48; O. Becker, *Das mathematische Denken der Antike*, 1957, pp. 37 f.—to name but a few. Even T. L. Heath, who was aware of the flimsiness of the evidence on which our knowledge of Thales is based, is inclined to over-estimate his achievements—cf. *History of Greek Mathematics*, 1921, i. 128 f.; *Manual of Greek Mathematics*, 1931, pp. 81 f.

[7] All three now only extant in meagre fragments, recently edited with a commentary by F. Wehrli, *Eudemos von Rhodos* (Die Schule des Aristoteles, Heft viii), 1955.

about Greek science before Euclid,[1] and there may well be a good deal of truth in this view. Unfortunately it does not help us at all in assessing the trustworthiness of Eudemus' statements about such an early figure as Thales, for two reasons. In the first place, if, as has already been shown, neither Aristotle nor Theophrastus possessed any written work by Thales, what reason is there to suppose that Eudemus had access to such? If he did not, then he knew no more about Thales than the other two did since he had to rely on the same inadequate sources; and therefore any achievement which later writers credit to Thales on the authority of Eudemus alone is likely to be a mere invention of his own or (as we shall see below) a rationalization of a presumed state of affairs in Thales' time. Secondly, there is some reason to suppose that Eudemus' works were lost quite soon after the fourth century B.C.[2] and that the same fate befell them as overtook Theophrastus' *Φυσικῶν δόξαι*, i.e. they were excerpted and rearranged by the epitomators, and then later writers took their quotations from these intermediate sources rather than from the original works. Proclus, from whose *Commentary on the First Book of Euclid* come most of the extant fragments of Eudemus' *Γεωμετρικὴ ἱστορία*,[3] although he usually quotes as though directly from the original (*ὥς φησιν Εὔδημος*), twice gives the impression that in fact he may be using intermediaries, when he mentions *οἱ τὰς ἱστορίας ἀναγράψαντες*[4] and *οἱ περὶ τὸν Εὔδημον*.[5] Even Simplicius, who purports to quote verbatim from Eudemus,[6] may have taken his quotation from a secondary source, for he says on one occasion, *ὡς Εὔδημός τε ἐν τῷ δευτέρῳ τῆς ἀστρολογικῆς ἱστορίας ἀπεμνημόνευσε καὶ Σωσιγένης παρὰ Εὐδήμου τοῦτο λαβών*.[7]

The authority of Eudemus is especially invoked to support the view of Thales as the founder of Greek geometry. The following propositions are commonly attributed to him:[8]

(1) that a circle is bisected by its diameter;
(2) that the angles at the base of an isosceles triangle are equal (the word actually used is *ὅμοιος* 'similar', instead of *ἴσος*);
(3) that when two straight lines intersect, the vertically opposite angles are equal;
(4) that if two triangles have two angles and one side equal, the triangles are equal in all respects.

For the first two of these, Eudemus is not specifically cited by Proclus as his authority, but it is generally assumed that they are derived from Eudemus[9]—how far this assumption is justified may be inferred from the following con-

[1] Cf. Martini in *P.W.* s.v. 'Eudemos'; Wehrli, op. cit., p. 114.

[2] Cf. Michel, op. cit., pp. 82–83, quoting Tannery.

[3] Wehrli, op. cit., pp. 54–67.

[4] Id. frag. 133 ad fin.

[5] Id., frag. 137.

[6] Id., frag. 140, p. 59, l. 24, *ἐκθήσομαι δὲ τὰ ὑπὸ τοῦ Εὐδήμου κατὰ λέξιν λεγόμενα.*

[7] Id., frag. 148. Heath, however, sees no reason to doubt that these late commentators of the fifth and sixth centuries A.D., such as Proclus, Simplicius, and Eutocius, consulted Eudemus at first hand (*Hist. of Gk. Maths.* ii. 530 f.; cf. *The Thirteen Books of Euclid's Elements*, 2nd ed. repr. 1956 (Dover Publications, New York), i. 29–38. Heath contradicts Tannery's view (cf. also Martini in *P.W.* s.v. 'Eudemos'; Heiberg, *Philol.* xliii. 330 f.), but offers no explanation of the passages I have cited above; he does agree that in the case of Oenopodes, for example, Proclus gives a quotation which cannot have been at first hand.

[8] Heath, *H.G.M.* i. 130 (cf. *Man.*, p. 83), v. d. Waerden, p. 87, Hauser, p. 45, and Becker, p. 38, give less well-authenticated lists.

[9] Cf. Heath, *Euclid*, p. 36.

siderations. As regards (1) it should be observed that Thales is said to have 'proved' (ἀποδεῖξαι) this, a statement which itself arouses suspicion since even Euclid did not claim to do this, but was content to state it as a 'definition' (ὅρος);[1] on the other hand, we are told that Thales only 'noted and stated' (ἐπιστῆσαι καὶ εἰπεῖν) (2) and 'discovered' (εὑρεῖν) without scientifically proving (3).[2] Most revealing, however, is the manner in which (4) is reported; here Proclus' actual words are,[3] *Εὔδημος δὲ ἐν ταῖς γεωμετρικαῖς ἱστορίαις εἰς Θαλῆν τοῦτο ἀνάγει τὸ θεώρημα. τὴν γὰρ τῶν ἐν θαλάττῃ πλοίων ἀπόστασιν δι' οὗ τρόπου φασὶν δεικνύναι, τούτῳ προσχρῆσθαί φησιν ἀναγκαῖον*, 'Eudemus in his "History of Geometry" attributes this theorem to Thales; for he says that Thales must have made use of it for the method by which, *they say*, he showed the distance of ships at sea' (my italics). This, as Burnet remarks,[4] is a clear indication of the real basis for all the statements about Thales' geometrical knowledge. Because his was the most notable name in early Greek history about whom various traditional stories were told (as in Herodotus), because he also had a reputation for putting his technical knowledge to practical use (hence the report—which was nothing more than hearsay, as *φασί* proves—of his measuring the distance of ships from the shore), and because it soon became firmly fixed in the tradition that he had learnt geometry in Egypt (on this see further below), then it seemed obvious to later generations brought up on Euclid and the logical, analytical method of expressing geometrical proofs, that Thales must certainly have known the simpler theorems in the *Elements*, which it was supposed he formulated in the terms familiar to post-Euclidean mathematicians. From this it was only a short and inevitable step to ascribing the actual discoveries of these geometrical propositions to the great man.[5] In fact, however, the formal, rigorous method of proof by a process of step-by-step deduction from certain fixed definitions and postulates was not developed until the time of Eudoxus in the first half of the fourth century B.C., and there is not the slightest likelihood that it was known to Thales.[6] He may have possessed some mathematical knowledge of the empirical type of Egyptian or Babylonian mathematics, but that this took the form which Proclus–Eudemus would have us suppose is quite out of the question.

Also regarded as stemming from Eudemus, although admittedly not his in its

[1] Euclid, *Elements* i, Def. 17.

[2] Cf. Heath, *H.G.M.* i. 131.

[3] Wehrli, frag. 134.

[4] *E.G.P.*, p. 45; cf. Gigon, op. cit., p. 55.

[5] There is an excellent modern example of this type of rationalization in the oft-repeated statement that the Egyptians of the second millennium B.C. knew that a triangle with sides of 3, 4, and 5 units was right-angled, and used this fact in marking out with ropes the base angles of their monuments; hence, it is said, they knew empirically this special case of the general 'theorem of Pythagoras'. In actual fact, there is no truth in this at all, and the whole story originated in a piece of typical guesswork by M. Cantor (whose *Vorlesungen über Geschichte der Mathematik*, 4 vols., 1880–1908, is probably responsible for more erroneous beliefs in this field than any other book—cf. O. Neugebauer, *Isis*, xlvii [1956], 58, for a just appraisal of it). Because Cantor thought that ropes representing a triangle with sides of 3, 4, and 5 were the simplest means for constructing a right-angle, he assumed that this was the method used by the Egyptians. Unfortunately, there is no evidence that they knew that such a triangle was right-angled; cf. Heath, *Man.*, p. 96; v. d. Waerden, p. 6.

[6] Cf. Neugebauer, *Ex. Sci.*, pp. 147–8. Its beginnings may be dated back to Hippocrates in the last half of the fifth century B.C., if he was really the first to compose a book of 'Elements' (στοιχεῖα) as Proclus says (in the 'Eudemian Summary'—see below—Wehrli, frag. 133, p. 55, 1. 7): cf. v. d. Waerden, pp. 135–6.

present form,[1] is the so-called *Eudemian Summary*, a brief, 'potted' history of geometry which Proclus prefixes to his *Commentary on the First Book of Euclid.*[2] It is here that we find for the first time the explicit statement that Thales went to Egypt and thence introduced geometry into Greece: *Θαλῆς δὲ πρῶτον εἰς Αἴγυπτον ἐλθὼν μετήγαγεν εἰς τὴν Ἑλλάδα τὴν θεωρίαν ταύτην [γεωμετρίαν] καὶ πολλὰ μὲν αὐτὸς εὗρεν, πολλῶν δὲ τὰς ἀρχὰς τοῖς μετ' αὐτὸν ὑφηγήσατο* (Wehrli, p. 54, ll. 18–20). Nowhere in the primary group of sources do we find Thales' name linked directly with either the beginnings of geometry or Egypt (or, for that matter, Babylonia); it is only in the secondary sources, and apparently first in Eudemus (if we assume that he is the authority for Proclus' account), that these connexions are made. This is worth emphasizing and is in itself very suggestive. It seems highly probable that the whole picture painted for us by later writers of Thales as the founder of Greek geometry on the basis of knowledge he had acquired in Egypt is nothing more than the amplification and linking together of separate notices in Herodotus.[3] The process seems to have been as follows: Thales was a prominent figure in early Greek history about whom practically nothing certain was known except that he lived in Miletus; Milesians were in a position to be able to travel widely; the two most interesting 'barbarian' civilizations known to the Greeks were the Egyptian and the Mesopotamian; therefore Thales (it was assumed) must have visited Egypt and Babylonia; but Herodotus[4] says that geometry originated in Egypt and thence came into Greece; therefore (it was assumed) Thales must have learnt it there and introduced it to the Greeks. It was left to modern commentators to add yet another stage to the myth by envisaging Thales (because of his alleged prediction of an eclipse) as the transmitter of Babylonian astronomical lore.[5] Once granted that Thales visited Egypt, then, of course, a number of other stories followed automatically. For example, it would naturally be assumed that he saw the most striking phenomenon of life in Egypt, the annual flooding of the Nile; Herodotus[6] reports three theories about this and in each case omits to name the originator; what more natural, therefore, than to appropriate the first of these for Thales?[7] Similarly it would be assumed that he saw the pyramids; therefore, the story followed that he measured their heights (Diels 21). The only surprising thing about these stories (apart from the seriousness with which modern scholars treat them[8]) is that there are not more of them.

[1] Cf. Heath, *H.G.M.* i. 118 f.; *Euclid*, pp. 37–38.

[2] Proclus Diadochus, *In primum Euclidis Elementorum librum comment.*, Prologus II, pp. 64 f. ed. Friedlein; Wehrli, frag. 133, pp. 54–56.

[3] Wehrli (op. cit., 115) points out that Eudemus follows Herodotus' view even in the face of a different opinion expressed by Aristotle.

[4] 2. 109; cf. Diod. Sic. 1. 81. 2; Strabo 757 and 787.

[5] In fact, a visit of Thales to Babylonia is even less well authenticated than a visit to Egypt—Josephus (*c.Ap.* 1. 2) seems to be the only writer to mention the former; but since Egyptian astronomy never evolved beyond a very elementary level and did not concern itself with eclipses (cf. Neug., *Ex. Sci.*, pp. 80–91; 95 ad fin.), some connexion between Thales and Babylonia had to be manufactured. This was made the more plausible by reference to Herodotus' statement (2. 109) that the Greeks learnt about the 'polos', the gnomon, and the division of the day into 12 parts (but on this see below) from the Babylonians.

[6] 2. 20 f.

[7] Aëtius 4. 1. 1 = Diels 16; cf. Diod. Sic. 1. 38.

[8] e.g. Gomperz, Gigon, Hölscher, and Hauser accept them all apparently without a qualm; Gigon (op. cit., p. 87) even accepts Cicero's story (*de div.* 1. 50. 112) about Anaximander's foretelling an earthquake.

Thus the Proclus–Eudemus invention of a visit to Egypt by Thales had an enormous effect on the later view of him and his achievements. The Egyptian civilization, whether because of the massive nature of its monuments or simply because of its antiquity, seems to have made a profound and ineradicable impression on the Greeks. This manifested itself in several ways; sometimes by a readiness to attribute to the Egyptians an immemorial knowledge of certain subjects, e.g. geometry; sometimes by a desire to give a respectable antiquity to a body of doctrine by inventing for it an Egyptian origin, e.g. the 'Hermetic' literature of the Alexandrian period;[1] and sometimes by a tendency to suppose that no life of a great man was complete without a visit to Egypt, e.g. Thales, and compare also the apocryphal stories about Pythagoras' and Plato's travels.[2] Once the travels became an integral part of the Thales tradition, then it was easy to draw a picture of him as the first Greek philosopher and scientist and the first to become acquainted with the knowledge of the Egyptian and Babylonian priests—a picture which suited well the preconceived ideas that later generations had of what must have happened in those early centuries, but which, it must be emphasized, is entirely hypothetical and unsubstantiated by any really trustworthy evidence. Modern commentators, by using every scrap of information gleaned from late sources, regardless of its genuineness but mindful of its plausibility, have enlarged the picture and even added to its colours so as to harmonize it with our greater knowledge of pre-Greek mathematics and astronomy. It still, however, remains a hypothetical picture, because it is not based on reliable evidence but on imaginary suppositions.[3]

The evidence we have points clearly to the fact that it was Eudemus, about 250 years after Thales, when already the famous names of early Greek history were dim figures of a remote antiquity about whom little definite was known, who was primarily responsible for using Thales as a convenient peg on which to hang an account of the beginnings of Greek mathematics. Thales' name was well known, there were already stories about his cleverness in Herodotus and Aristotle, and no written work of his remained to contradict whatever doctrine might be assigned to him; he was, in fact, an ideal choice. Once the connexion had been made between him and Egypt, then everything else fitted nicely into place. There is nothing surprising in such a process. The distortion of historical fact in later tradition and the ease with which purely imaginary accounts,

[1] This was represented as part of the divine teaching of the ancient Egyptian god Thoth (Greek, Hermes) and his interpreters, Nechepso and Petosiris; cf. A.-J. Festugière, *La Révélation d'Hermès Trismégiste*, 4 tom. (1944–54)—especially tom. i, pp. 70 f.

[2] Cf. Burnet, *Early Greek Philosophy*, p. 88; G. C. Field, *Plato and His Contemporaries*, 2nd ed. 1948, p. 13.

[3] There is a curious dualism evident in most of the modern accounts of Thales. Even those scholars who profess to recognize the unsatisfactory nature of the evidence on which our knowledge of him depends continue to discuss his alleged achievements as though they are undoubtedly real. Despite the occasional qualifying phrase (e.g. 'Thales is said to . . .', 'tradition has it that Thales . . .', and so on), the desire to believe is so strong that his travels, for example, are now treated as an established fact. One result of this is that the notices about Thales in classical dictionaries and encyclopedias are for the most part uniformly bad; especially misleading are those in *P.W.*, *O.C.D.*, and the *Encyclopaedia Britannica*—Chambers's is slightly better, while Tannery's in *La Grande Encyclopédie*, tom. 30 is eminently sensible. It is noteworthy that some American scholars in recent years are at last realizing how little is really known about Thales: cf. D. Fleming in *Isis*, xlvii [1956], reviewing *Essays on the Social History of Science* (Centaurus 1953); M. Clagett, *Greek Science in Antiquity*, 1957, p. 56.

buttressed by one or two circumstantial details, can be rendered entirely plausible could be demonstrated by numerous examples; one thinks of the mighty epic of Roland and its slender basis of fact in an unimportant border skirmish,[1] and the famous story of the First World War about the Russians marching through England with 'snow on their boots'. The legend of Thales built up by the later commentators is simply another more prosaic example of a similar type. Admittedly the lateness of a source does not in itself entirely destroy its worth as a trustworthy authority, but it should at least make us look more closely into the antecedents and origin of the information provided. When, as Diels has clearly shown, this information is based on intermediaries copying and recopying from each other at third, fourth, and fifth hand, then the value of the late source is, I submit, negligible, and the data it provides likely to be unauthentic and misleading. This is especially true of the early Ionian thinkers who, as we have already seen, even to Aristotle's generation tended to be mere names attached to various traditional stories. Anything new, however plausible, that Proclus tells us about Thales must be taken with more than the proverbial grain of salt.

What view, then, based on reliable evidence, are we to take of Thales, having rejected the testimony of the secondary group of sources? We may accept it as a fact that he was a man of outstanding intelligence, for this is implicit in all the references to him in the primary sources; we may also take it that he speculated on the origin and composition of the universe and came to the conclusion that the primary substance was water—this is well attested, but the original statement was soon embellished by later writers and these embellishments were likewise attributed to Thales.[2] Finally, we may, on the evidence of Herodotus' story of the prediction of the eclipse and (but much more dubiously) the alleged diversion of the river Halys, regard it as highly probable that Thales interested himself in mathematics and astronomy and possessed for his time a more than average knowledge of both. If we wish to know what this knowledge consisted in, there is (owing to the lack of an original source and the scarcity of reliable evidence) only one legitimate means by which we can find out, namely, by a comparative examination of the mathematics and astronomy of Thales' time, and this means in effect Egyptian and Babylonian mathematics and astronomy, for these were the only highly developed civilizations with which the early Greeks came into close contact. This is most definitely not to assert that Thales visited either Egypt or Babylonia; the evidence that he did is, as we have seen, late and unreliable, and we are not entitled on the strength of it to build up elaborate theories about his travels and the knowledge he is supposed to have acquired on them. He *may* have made a tour of the whole Aegean coastline, he *may* have been conducted up and down the Nile and the Euphrates to the accompaniment of a continuous stream of information supplied by priestly guides, and he *may* have crossed the Mediterranean from east to west and north to south sailing entirely at night; there is just as much or just as little evidence for all this as there is for the traditional picture of him as the transmitter of Egyptian and Babylonian wisdom. If, however, we are prepared to believe that he was conversant with the mathematical knowledge of his time, then this must have been of the type of Egyptian and Babylonian mathematics —regardless of whether he actually visited the countries—because there

[1] Rhys Carpenter, *Folk Tale, Fiction and Saga in the Homeric Epics*, repr. 1956, pp. 39–40.

[2] See the article by Snell, already quoted.

existed no other to which he had access. It is, therefore, only by examining the contents of pre-Greek[1] mathematics that we can estimate what Thales could have known as distinguished from what later commentators supposed he knew. It is useless to try to reason backwards and reconstruct, as Eudemus apparently did, what Thales 'must' have known from the standpoint of Eudemus' own period, for by that time the formal, Euclidean type of mathematics (which is the characteristically Greek contribution in this field) had been firmly established, and if there is one thing that is quite certain it is that this type of treatment was completely foreign to Egyptian and Babylonian mathematics.

This is not the place for a detailed description of them,[2] but a few salient points may be noted. Both the Egyptian and the Babylonian mathematicians knew the correct formulae for determining the areas and volumes of simple geometrical figures such as triangles, rectangles, trapezoids, etc.; the Egyptians could also calculate correctly the volume of the frustum of a pyramid with a square base (the Babylonians used an incorrect formula for this), and used a formula for the area of a circle, $A(\text{area}) = (\frac{8}{9}d)^2$ where d is the diameter, which gives a value for π of 3·1605—a good approximation.[3] These determinations of area and volume were closely connected with practical problems such as the storage of grain in barns of various shapes, the amount of earth needed in the construction of ramps, and so forth. It is especially noteworthy that in both Egyptian and Babylonian geometry the treatment is essentially arithmetical; in the texts the problem is stated with actual numbers and the procedure is then described with explicit instructions as to what to do with these numbers.[4] There is little indication of how the rules of procedure were discovered in the first place and no trace at all of the existence of a logically arranged corpus of generalized geometrical knowledge with analytical 'proofs' such as we find in the works of Euclid, Archimedes, and Apollonius. Hence even if we wish to assume that Thales visited Egypt (for which—let it be repeated—there is no reliable evidence) all he could have learnt there (and even in this he would probably have had considerable difficulty, for there is no evidence that any Greek of Thales' time could read Egyptian hieroglyphics)[5] was some empirical data about the simpler geometrical figures, not theorems of the type that Eudemus attributes to him. Egyptian mathematics is essentially additive in character (multiplication and division are reduced to a cumbersome process of successive duplication, the sums of the factors being then added to give the required answer),[6] and also operates entirely with fractions having 1 as the denominator, with the single exception of $\frac{2}{3}$; it is obviously unsuited to extensive calculations such as are necessary in astronomical problems, and has

[1] Both Egyptian and Babylonian mathematics were already highly developed by the beginning of the second millennium B.C., and both remained largely static until Hellenistic times.

[2] Excellent accounts are given by O. Neugebauer, *The Exact Sciences in Antiquity*, 2nd ed. 1957 (with full references to the relevant literature), and by B. L. van der Waerden, *Science Awakening*, 1954 (despite an exaggerated and misleading treatment of Thales).

[3] The Babylonians commonly used the rough figure $\pi = 3$, but one text implies the more accurate value $\pi = 3\frac{1}{8}$; cf. Neugebauer, op. cit., p. 47.

[4] Cf. v. d. Waerden, pp. 63 f.

[5] Cf. Burnet, *Early Greek Philosophy*, p. 17. The passage in Herodotus (2. 154) about 'interpreters' significantly mentions only Egyptians sent to the Greek settlements in Egypt to learn the language, and says nothing of Greeks learning Egyptian; nor is there any mention of writing.

[6] Cf. Neug. p. 73.

been described as having 'a retarding force upon numerical procedures'[1]—very unlike the extremely flexible Babylonian system of numeration. There is not the slightest evidence or likelihood that the Greeks of Thales' time, or for several centuries afterwards, understood the Egyptian methods.[2] Only in the late Hellenistic period do we begin to find traces in Greek writers of the existence of a type of mathematics which is very different from the classical Greek mathematics of Euclid and Archimedes, and which has its origins in the Egyptian and Babylonian procedures and forms 'part of this oriental tradition which can be followed into the Middle Ages both in the Arabic and in the western world'.[3] Similarly, there is not the slightest justification for supposing that Thales was conversant with the sexagesimal system with its place-value notation which was the invaluable contribution of the Babylonians to later Greek mathematical astronomy. There is evidence to show that neither the sexagesimal system nor the general division of the circle into 360° (also a Babylonian invention) was known to the Greeks before the second century B.C., and that probably Hipparchus (c. 194–120 B.C.) was responsible for at least the introduction of the latter into Greek mathematics.[4]

Detailed knowledge of things Babylonian seems only to have reached the Greeks at a comparatively late period; Herodotus tells us practically nothing about their literature or their science and displays only a limited knowledge of their history.[5] It is generally considered that the source from which the Greeks obtained most of their knowledge about Babylonian culture was Berossus, a Babylonian priest who is supposed to have set up a school in Cos about 270 B.C. and to have produced works on Babylonian history;[6] certainly, in the second century B.C. Hipparchus was familiar with the results of Babylonian astronomy. There is, however, no evidence that the Greeks before the third century B.C. knew much more about the Babylonian civilization than Herodotus did. Thus the modern myth-makers' determined efforts to manufacture a connexion between Thales and Babylonia are as fruitless as they are without foundation; even had he visited that country there is again no evidence and no likelihood that he could read the cuneiform script.

To sum up—there is no reliable evidence at all for the extensive travels that Thales is supposed to have undertaken; his mathematical knowledge could hardly have comprised more than some empirical rules for the determination of elementary areas and volumes; his astronomical knowledge must have been

[1] Id., p. 80.

[2] Van der Waerden (p. 36) is very misleading here. The difference between the classical Greek and the Egyptian methods of multiplication and division is clearly shown by Heath, *Manual*, pp. 29 f.

[3] Neug., p. 80.

[4] The arguments and the evidence cannot conveniently be presented here, but I hope to discuss them in a further article. Meanwhile it should be noted that A. Wasserstein's curious paper 'Thales' Determination of the Diameters of the Sun and Moon' (as remarkable for its disregard of recent modern work in this field as for its inconclusiveness) in *J.H.S.* lxxv (1955), 114–16, contains little but unwarrantable assumptions based on unreliable evidence.

[5] Cf. W. W. How and J. Wells, *A Commentary on Herodotus*, repr. 1950, i. 379–80. The only Greek borrowings from the Babylonians that Herodotus mentions are of the 'polos' (a portable, hemi-spherical sun-dial), the gnomon, and the division of the day into 12 parts (in this he is only partly correct, as it was the day-and-night period that was divided into 12 parts).

[6] Cf. P. Schnabel, *Berossos und die babylonische-hellenistische Literatur*, 1923. It must, however, be said that Schnabel's conclusions regarding Babylonian astronomy are now untenable, and his arguments in support of the great influence of Berossus' writings are very speculative and far from conclusive.

similarly elementary (probably comprising nothing more scientific than the recognition of some constellations),[1] since there is not the slightest likelihood that he was familiar with the complicated linear methods of Babylonian astronomy, and Egyptian astronomy was of a very primitive character; on the other hand, he might possibly have heard of the 18-year cycle for lunar phenomena and might somehow have connected this with a solar eclipse so as to give rise to the story that he predicted it; there is no reason to disbelieve the early stories of his political and commercial sagacity, or the fact that he considered the primary matter of the universe to be water; everything else that is attributed to him by later writers in the secondary group of sources (including Eudemus) can be disregarded.

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[1] Kirk and Raven's description (op. cit., pp. 81–82) of Thales' astronomical activities is far too optimistic. Some idea of the primitiveness of the astronomical ideas then current may be gained from the peculiar notions of his successors such as Anaximander, Anaximenes, Xenophanes, and Heraclitus, which Heiberg (*Gesch. d. Math. und Naturwiss. im Altert.*, 1925, p. 50) rightly characterizes as 'diese Mischung von genialer Intuition und kindlichen Analogien'.