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## THE DEBT OF GREEK PHILOSOPHY AND SCIENCE TO THE ANCIENT NEAR EAST

### INTRODUCTION

As its informal style and lack of footnotes no doubt suggest, the paper published under the title 'The debt of Greek philosophy and science to the ancient Near East' in *Peddlawim* in 1982 originated in a public lecture. An earlier version was first given in Birmingham, as the Rundle Clark Memorial lecture in 1976, and the version published corresponds fairly closely to an address to the Japanese Classical Society in 1981. In an occasionally provocative and at points deliberately oversimplifying way, the paper attempts both to suggest certain ground-rules for comparative studies and to set out some broad theses with respect to the particular problems posed by the relationship between the philosophy and science of the ancient Greeks and the theories and practice of their immediate ancient Near Eastern neighbours.

So far as the ground-rules for any such study go, there was, I would now say, little exaggeration in my emphatic insistence on the need to be wary of the grand generalisation. The validity of the point I made (p. 283) that the circumstances of influence or transmission vary importantly as between the four fields I mentioned (technology, religion and mythology, mathematics and astronomy, medicine) has not diminished. Although we can use those general characterisations of broad aspects of the culture of the ancient civilisations concerned, not only must we be prepared to draw distinctions between these four where any single culture is in question, but we also cannot afford to assume that the intellectual or social position, aims or preoccupations of any one field in one culture will be identical with those in any other. Medicine, no doubt, is always directed to healing the sick; but the conception of what it is that needs healing, the role or roles of the often diverse types of person who practise healing, may vary drastically from one culture to another. Again while broad comparisons are possible between one religion and another, one mythology and another, their place cannot be assumed to remain fixed and stable in all cultures – and the same must also be said even of mathematics and astronomy.

My particular concern, in this study, was with the archaic and classical periods when the actual communications between Greece and the Near East were limited. Of course the picture becomes appreciably more complex for

later periods when there is evidence of far more extensive direct contacts, and not just between Greece and the Near East, but rather between much of the Greco-Roman world and the Middle and Far East. Yet that similar detailed investigations are possible has been shown, above all, by Joseph Needham's discussions in his *Science and Civilisation in China*. Here too it is clear that just how particular ideas, knowledge, myths, techniques travelled, and why some did easily and others only very slowly, are questions that have to be resolved case by case. There are indeed as many interesting problems relating to the *failure* of transmission, when cultural contact existed, as there are to successful transmission, as many questions that are worth raising about the presuppositions that favoured or impeded influence as about the adaptation of the ideas and techniques actually transmitted.

As for my own rapid *tour d'horizon* of what might be said, for the archaic and classical periods, about Greek philosophy and science, I would now observe that the perspective from which I discussed philosophy was very much a Greek one, as, for example, when I wrote (p. 297) that philosophical inquiry as such is a Greek invention. That is true of the style of philosophy that we have inherited from the Greeks – and the points I made concerning the differences between that style of inquiry, and myth, hold subject to that qualification. But of course if I had taken a wider perspective and considered modes of philosophising that take different forms, the claim concerning the Greeks rapidly becomes transparently absurd. India and China both had their distinct philosophical, as well as their religious and scientific, traditions. However, from the point of view of what the Greeks might have learnt from Egypt or Babylonia, our evidence still suggests that that would not have extended as far as philosophy, construed as the argumentative, rational or would-be rational inquiry that it was for most Greeks.

Here too much further work needs to be done, and the issues will undoubtedly prove to be more convoluted than even the complexities of the material I discussed. The analysis of the origins of science, technology and philosophy in any given culture, and of what they may or may not owe to outside influences, is just the first step towards the analysis of the culture as a whole. That first analysis takes one into problems not just of an intellectual or internalist nature, but, as I acknowledged but could not follow up in my article, into issues concerning the whole background of the social, political and ideological conditions that accompanied the development of the distinctive *styles* of science and philosophy in question. My original paper set an agenda, in other words, and does no more than outline aspects of the answers in relation to the ancient Greeks and their Near Eastern neighbours.

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#### THE DEBT OF GREEK PHILOSOPHY AND SCIENCE TO THE ANCIENT NEAR EAST

To reopen so venerable a topic as the debt of Greek philosophy and science to the ancient Near East calls for some words of explanation. The topic goes back, after all, to the Greeks themselves. Ancient Greek attitudes towards their Near Eastern neighbours underwent several transformations – not that we should think of those attitudes as uniform or universal at any period. Two phases, in particular, stand out, very broadly speaking, a phase of discovery and one of syncretism. First there is the great upsurge of interest from the mid-sixth century, continuing through the fifth and fourth, a period when Greek knowledge of the Egyptian and Babylonian civilisations especially increased tremendously and when we find evidence of the deep impression those civilisations made upon the Greeks in one major Greek author after another. Herodotus' admiration for Egypt and Babylonia is obvious in his detailed descriptions of them (that of Egypt, at least, based on first-hand acquaintance). Nor need I remind you that there is a series of references in Plato (some more serious than others, to be sure) to the antiquity of the Egyptian race and to several of their more notable cultural achievements.

The second phase, that of syncretism, was already advanced by the turn of the millennium, as we can see from Diodorus and Strabo, for example. Even in Herodotus' day, the Egyptian priests whom he quotes claimed that Egypt was the source of much Greek religion. By the time we get to Diodorus, the list of those Greeks who – according to the Egyptians – got their ideas from Egypt has grown fantastically. It now includes Orpheus, Musaeus, Melampus, Daedalus, Homer, Lycurgus, Solon, Plato, Pythagoras, Eudoxus, Democritus and Oenopides. The priests whom Diodorus cites put it bluntly that 'all the things for which [these men] were admired among the Greeks were brought from Egypt'. The tendency to assimilate Greek and Near Eastern wisdom, and to see the latter as anticipating Greek philosophy, grows still further in the early Christian period. Thus Clement of Alexandria, who quotes Numenius for the idea that Plato is really Moses writing Attic, sets out systematically, in his *Stromateis*, to prove that Greek philosophy was anticipated by the wisdom of the prophets and that the Greek philosophers plagiarised what they present as their own ideas from the East.

But if ancient authors initiated the debate, the continuation of the controversy forms an important strand in the transmission of Greek learning through the Middle Ages down to the Renaissance and beyond. The fortunes of the two opposing views (of Greek originality, § and of Greek derivative-ness) shift from one generation to another and I cannot do justice to that aspect of the question here. But Stevin, for example, was one important scientist who believed in an oral, unwritten wisdom in what he calls the Age of the Sages long before Presocratic philosophy, and Isaac Newton himself

wrote a treatise on 'the chronology of ancient kingdoms amended' to establish a similar thesis. In the nineteenth century similar battle lines are drawn up. Thus a prominent section in the introduction to Zeller's classic *History of Greek Philosophy* was devoted to refuting the theses of Röhrlach and Gladiach. According to Gladiach, for instance, 'the Presocratic systems reproduced without any material alteration the theories of the universe of the five chief Oriental nations', that is Chinese, Hindus, Persians, Jews and Egyptians.

Many of the contributions to this immensely long-drawn-out debate have been highly charged with emotive language. Indeed it has been so long drawn out partly because 'Greece' and the 'Near East' have often been used as a polar antithesis, 'Greece' being taken to stand for reason, the 'near East' for Faith, Religion, Mysticism or The Irrational – as if (apart from all the other points that such an antithesis ignores) the Greeks did not have their own religion, indeed their mystery religions, and as if, conversely, the Egyptians and Babylonians did not excel in such hard-headed practical matters as the administration of large-scale empires. It was, on this own account, partly because he was provoked by this type of gross oversimplification that Dodds wrote the book, *The Greeks and the Irrational*, which has, ever since its appearance in 1951, been largely instrumental in producing a swing away from the earlier drastically misguided identification of the Greeks with pure reason.

But why, then, reopen a subject which has been the occasion of so much anti, prejudiced and unscholarly posturing? I am not going to claim that we have now achieved some Olympian height from which we can adjudicate on the dispute, though I would claim (I have just claimed) that we may be in a better position than many of our predecessors to see that some of this debate has not really been about what it purports to be about at all. It has not been a historical study, but a pretext for the debaters to air their own views about the relative merits of Reason and the Irrational. But when we have progressed beyond that point, and beyond the point of merely distributing compliments or criticisms to the Greeks and to their various Near Eastern neighbours, there are important issues to be discussed concerning the question of the origin or invention of philosophy and science themselves. The two fundamental problems here are first what sort of development in thought are we to suppose that they involved (and in particular should we see the origin of philosophy and science in terms of a gradual development or of some revolutionary change or breakthrough)? And secondly (though this is not a question I shall be able to follow up today) what were the social, political and ideological conditions that accompanied this development or revolution? If we are to get clear on these questions, we must indeed try to come to terms with the problem of the relations of the Greeks to the Near East. Many aspects of those relations are – and in the absence of new evidence must remain – highly obscure, and we must acknowledge that fact.

But some detailed work recently undertaken in a number of different inquiries has made it possible to be clearer on certain aspects of the problem. I aim to collate points from some of this recent work to arrive at some provisional conclusions on some features of the question.

In considering what the Greeks may or may not have taken over from their ancient Near Eastern neighbours, we must first recognise the great variety of different fields of possible influence and the fact that each different field poses its own problems. Four of the main areas that will concern us are (1) technology, (2) religion and mythology, (3) mathematics and astronomy and (4) medicine. But what on the one hand enabled or facilitated, and what on the other impeded, the transmission of ideas varies with the field in question – a simple point that has, I fear, too often been ignored. Thus the circumstances in which a metallurgical technique may be transmitted are quite different from those of the transmission of a religious belief or myth, which differ in turn from those of a piece of astronomical lore, which differ in turn from those of a method of cure. In particular the extent to which the transmission must be mediated *through language* differs, and so too does the extent to which the transmission is effected between individuals who already possess *specialised* knowledge. Thus there may be less formidable barriers to communication between two specialists of different cultures, than between a specialist and a layman from the same culture. The English and the Russian mathematician may well communicate more freely (even without knowing each other's natural language) than the English mathematician and the man in the street; and the same may also be true, on occasion, of the English and the Russian medical man, although in considering both these examples we must be aware that the easy communication between modern specialists reflects the standardisation of much specialist knowledge – while the question of how far there was any such standardisation in the ancient world is, of course, one of our main problems.

After these preliminaries, let us consider each of the four main fields I have identified in turn, and first, briefly, technology. No one seriously doubts, I imagine, that most of the basic techniques used in the Greek world in the classical period in such areas as agriculture, metallurgy, textiles, even pottery, had arrived there as the result of a long process of diffusion whether from the Near East or elsewhere. I am thinking, for example, of the use of the plough, of that of the potter's wheel and of the wheel for transport, of the main techniques of spinning and weaving, and of those of the extraction and working of metals (hammering, melting, casting). In some cases, of course, the hypothesis of independent development of the same or a similar technique in different parts of the Near East and eastern Mediterranean basin cannot be ruled out and may even be preferred. But that some diffusion took place is agreed on all sides, even though *how* that diffusion took place is very much a matter of guesswork: the fact that many craftsmen were itinerant may be one factor, but we must set against that their usual extreme

conservatism, at least to judge from the evidence from the historical period. The process stretches back to the third millennium at least, and continues, sporadically, in the historical period, where we are sometimes in a position to date, within broad limits, the introduction of new technological devices, such as the screw-press or the water-wheel.

Yet if we ask how important the development of technology was for the growth of philosophy and science, the answer must be only slightly so. The idea that ancient natural philosophers were *never* interested in technology, *never* concerned to apply their ideas to tame and exploit natural forces, has been much exaggerated (one thinks not only of Archimedes, but of Ctesibius, Philo, Hero of Alexandria and Vitruvius). On the other hand it is fair to say that the dominant motive in philosophy was understanding or wisdom, and that the connections between science and technology were far less extensive in the ancient world than they are today.

The period we must focus on is that from, say, the eighth to the sixth century, the period leading up to the practice of the enterprise that we can identify reasonably confidently as *philosophy* and *science* more or less as we know them. Certainly two extremely important developments that may, on a somewhat generous acceptance of the term, be called 'technical' or 'technological' do occur in this period, namely the introduction of coinage (diffused from Lydia, according to Herodotus) and that of the alphabet (where the chief debt of the Greeks was to the West Semitic group of languages). Clearly these developments had an immense impact on the Greek world, and so indirectly on everything that happened within it. Yet it would be hard to claim that either was directly responsible for bringing about the development of philosophy and science. Literacy was, no doubt, essential for the spread of philosophical and scientific inquiry. Equally we may suppose that neither could have been produced except in a society whose economy had the sort of flexibility guaranteed by coinage. Yet even if both these factors (along with many others) may be *necessary* conditions for the development of philosophy and science, neither can by itself (nor can they jointly) be a *sufficient* condition. We have only to reflect that coinage was common to many other peoples in the ancient Near East where there was no  $\parallel$  speculative thought of the type practised by the Greek philosophers, and that the same is true (though to a much more limited degree) of the use of an alphabetic system of writing. Although there are certain exceptions, there is a striking overall *homogeneity* in the level of technology throughout the Near East and eastern Mediterranean basin in the period that concerns us. In this area, the Greeks were undoubtedly chiefly beneficiaries, receivers rather than givers. Yet that very homogeneity suggests that the topic is only of limited usefulness and relevance to our attempt to understand the growth of distinctive modes of speculative thought.

Our second field of inquiry, religion and mythology, yields, or has been thought to yield, much richer material for our debate. In recent years the case

for the relevance of mythical antecedents to the earliest Greek philosophy has been argued forcefully by a series of outstanding writers, notably Frankfort (*Before Philosophy*), Cornford (*From Religion to Philosophy*) and *Principium Sapientiae*. Kirk and Raven, and M. L. West. It is particularly striking that in Kirk and Raven's handbook entitled *The Presocratic Philosophers*, the longest single chapter should be devoted to 'the forerunners of philosophical cosmogony', i.e. myth. Yet the problems that any such thesis faces are formidable, and though some of these have been fully recognised by its advocates, others (particularly some that stem from recent anthropological studies of myths) have been rather neglected. A brief summary of some of the general difficulties that the thesis must face is in order before considering some particular case-histories.

First, while there is no problem in supposing that the earliest Greek philosophers were familiar with their own, Greek, mythologists (such as Hesiod), the idea that they were aware of Egyptian, Babylonian or Hittite myths is – we must remember – an *assumption*. It is one that has greater or less plausibility in different cases, depending on the answers to two questions: first how good is the evidence that the philosopher himself travelled in the Near East, and second what is he likely to have learned from Milesian or other traders who did travel? That Milesius was especially active both in trade and in founding colonies is well established. That Thales travelled to Egypt is possible. That Anaximander drew the first Greek map is probable, though we do not know how far it was based on first-hand experience. Yet when Plutarch and Simplicius, for instance, conjecture that Thales was familiar with Egyptian myths, that is, of course, simply a *conjecture*, as are modern suggestions of a similar kind. It is true that the source of a Greek idea is sometimes represented not as an Egyptian, Babylonian or Hittite myth itself, but some archetype from which all the variant versions are derived; but that still involves plenty of conjecture, indeed *more* than the thesis of direct influence.

Secondly, there is the problem of distinguishing fortuitous  $\parallel$  from non-fortuitous parallels or similarities. Alongside Egyptian or Babylonian material used to interpret Greek ideas, we often find cited Maori or Scandinavian myths. Yet where the 'parallelism' is just as marked with a Maori as with an Egyptian myth, such non-Near-Eastern material provides the basis of a counter-argument to the thesis of direct influence, even though this does not always seem to be recognised. If a particular idea or belief can be 'paralleled' in a culture where it is impossible to postulate direct or indirect influence, this will tend to weaken the claim of direct influence even where there is that possibility.

This takes me immediately to a far more fundamental third point. Since structuralism has – for all its excesses – proved such a powerful tool of interpretation in the study of myths, there has been a transformation in the view taken by anthropologists on the question of the elements to be taken as

the basis of comparison in cross-cultural inquiries. The essential point is that it is no good taking *individual* motifs (such as the Sky God, or the castration motif) and comparing *these* across cultures. The basis of the comparison must be not the isolated motif, but the *complex*, for it is only within a complex structure that any individual item can be understood even within a single culture. But when we accept that principle, the similarities between Greek and non-Greek mythologies begin to look far less impressive.

Fourthly and finally a distinction must be observed between the transmission of mythical ideas from one culture to another, on the one hand, and the influence of myth on *philosophy*, on the other. When we are considering the Milesian philosophers and their successors, the question can and should always be asked: what did they *see* in the particular myths that are thought to have influenced them? Why did any particular Presocratic choose the particular myth he did? How did he use the idea he derived from it? This raises fundamental questions about the nature of the philosopher's activity, and of his entitlement to be called a philosopher. Yet the distinction in aim between a Hesiod and a Thales must always be borne in mind in evaluating their handling of, or response to, mythical beliefs.

Now to apply these principles to some actual examples – and I have, of course, to be highly selective – first to Thales' water, then to Anaximander's Boundless, and then to Heraclitus' fire. In assessing the suggestion that in postulating water as the origin of things Thales was influenced by ancient Near Eastern myths, and in particular by the Babylonian myth of Tiamat and the Egyptian one of Nun, we must first set those mythical figures in their respective complex, and quite different, contexts. Tiamat, as Kirk himself put it, is a primeval water goddess whom Marduk splits, making one half the sky (and the celestial waters) and one half Apsu the deep and Esharra, the 'great abode' or firmament of earth. But before this splitting takes place, we'll have an account of the state of things at the beginning of the poem, *Enûma Elish*, that runs as follows: 'when on high the heaven had not been named, firm ground below had not been called by name, naught but primordial Apsu, their begetter, (And) Mummu-Tiamat, she who bore them all, their waters commingling as a single body...'. Jacobsen commented on this: 'the chaos consisted of three intermingled elements: Apsu, who represents the sweet water; Tiamat, who represents the sea; and Mummu, who cannot as yet be identified with certainty but may represent cloud banks and mist'. Even accepting *that* interpretation of the text, it is obvious that we have no *simple* story. Even if we have three different aspects of water, we already have male and female principles, a begetter and a bearer – and of course neither the splitting of a Tiamat into two, nor the copulation of Apsu and Tiamat, has any analogue in our admittedly very limited information concerning Thales. In Egypt too the myth in question is a complex one. Nun is the primeval water, but there are, as Wilson tells us, four pairs of gods 'who were before the beginning', that is not only Nun and his consort Naunet (who becomes

the counter-heaven), but also Hub and Hauhet, Kuk and Kakaet, Amun, Amon the hidden – and Amaunet. The eight are, no doubt rightly, seen as representatives of chaos or disorder, in contrast with the Nine, Ennead, beginning with Atum, who represent order. But again we may note a certain complexity – and one must add that Atum himself was there in Nun. It is not the case that what we have in Egypt and Babylonia are *clear, simple and unequivocal* statements of the idea that everything came from water – simple stories to that effect complicated merely by the addition of transparently non-essential embroidery. Tiamat and Nun are both parts of complex and rich wholes: notably in both cases the motif of sexual reproduction is there from the beginning.

So even if we assume, then, that Thales was acquainted with, and impressed by, those Near Eastern myths, we must remark that he has simplified them, and we may legitimately ask not only (1) why he did so, but also (2) why he selected these myths from among quite a wide range of creation stories current in both Egypt and Babylon (they include other examples of the idea that things are created by their being named). We are led back, then, to the question of what Thales' aims were – or rather, in the state of our evidence, what they could conceivably have been. Clearly his aim was not to produce yet another *myth*. If we accept Aristotle's account at all, it was *water, ὕδωρ*, that Thales spoke about, and not, for example, a figure such as Oceanos who already had an established place in Greek mythology – even though Aristotle does mention the possibility that Thales was impressed by the idea that Ocean was the father of gods. Aristotle, let us recall, does not claim to know *why* Thales chose water, starting his comments on this question with the words '*perhaps* he [Thales] got the idea from...', but in those 11 comments Aristotle begins by canvassing a variety of naturalistic factors, the observation that food is moist, that water is essential for life and so on. Although so much remains obscure, one thing does seem clear if we are to say anything about Thales' cosmogony at all, and that is that he was *not* simply *imitating* any myth, whether Greek or non-Greek. At the very most he was selecting and critically evaluating mythical ideas, and Aristotle at least would represent him (conjecturally) as having been influenced by naturalistic considerations above all. Now it may be that Thales was also influenced by myth – that he was impressed by stories involving Tiamat and Nun. That is a positive contribution to the stock of conjectures about the background to his work. Yet (1) we must be clear that there is no compelling necessity to say even that much, and (2) nor should we underestimate the *gap* that would still remain between Thales and any Egyptian or Babylonian – or Greek – mythologist.

Anaximander's Boundless, my second example, is from one point of view a more complex problem (the evidence is richer, though still sparse enough) but from another – from the point of view that concerns us here in discussing Greek debts to the Near East – a simpler one. Cornford's argument was that



philosophy is a distinctive enterprise, marked out by, and indeed defined in terms of, its own aims and methods. Unlike the person inventing or recounting a myth, the philosopher offers an account that, implicitly or explicitly, claims to be true according to criteria that are subject to scrutiny. His theses are arrived at, and supported or defended, by reasoned arguments and (where appropriate) appeals to evidence. That may seem an excessively charitable view of Presocratic philosophy, much of which seems, after all, highly dogmatic. Nevertheless it can, I believe, be justified, certainly from Parmenides onwards, and if my and the usual interpretation of Anaximander is correct, then also earlier still, from him, if not from Thales himself. The adaptation of the theses and ideas from Greek and non-Greek myths and religion should (let me repeat the point yet again) certainly *not* be ruled out. But what Greek philosophy took over from such sources, it generally recast in a new, dialectical, framework. Let me give a final illustration from a later period where our evidence is more reliable. It is clear from the *Politicus* (for example) that Plato did know something of Zoroastrian dualism, the idea of two opposed cosmic forces, one good and the other evil. It so happens that Plato rejects this doctrine, though there was nothing that ruled out his accepting it and something like it may, in fact, have been maintained by Empedocles, although whether *he* knew of Zoroastrianism is more doubtful. Yet the point is that as philosophers both Empedocles and Plato were committed to explain, defend and give arguments for || such theses as they advanced. Even Empedocles did so, telling us what is meant by Love and attempting to justify the claim that it is at work in the cosmos as a whole in Fr. 17. More clearly still, Plato does not merely assert his own position as against alternative views, but provides detailed metaphysical and epistemological arguments to support it and to refute those of his opponents, not only in the *Politicus*, but also in the *Republic* and *Timaeus* and most notably of all in the tenth book of the *Laws*.

If my point about the *distinctiveness* of the philosophical enterprise is accepted, then attempts to make *direct* comparisons between philosophy and myth and to identify the debts of the one to the other (whether to Near Eastern or to Greek myths) must be subject to that all-important reservation. But we can now turn to subjects where Near Eastern and Greek work can, on the face of it, be compared directly, and first to mathematics and astronomy: I say 'on the face of it', since again certain differences of aim will emerge. In these areas, particularly in astronomy, tremendous progress has been made, in recent years, in studying both ancient Near Eastern and Greek work, and we are now in a far better position than we used to be to assess the possibilities of influence in fairly precise terms, though this can, of course, be no more than a rapid survey.

Take first arithmetic, where we must begin by noting the *heterogeneity* of the systems of notation developed in the ancient world. The Babylonians had both a decimal and a far more important sexagesimal system: the latter,

based on the place-value principle, was enormously influential in astronomy, to which I shall be turning later. But outside astronomy too we may remark occasional signs of the possible influence of sexagesimal arithmetic in Greek culture, in, for example, the division of the talent into 60 minae (already in the Mycenaean period).

Yet so far as Greek arithmetic (*logistikē*) itself goes, an Egyptian influence looks more promising. Like the Greek, the Egyptian system was a decimal one. In it fractions (with the exception of  $\frac{2}{3}$ ) were all treated as submultiples or single aliquot parts (i.e. the numerator was always one: thus 0.4 was treated not as  $\frac{2}{5}$ , but as  $\frac{1}{5} + \frac{1}{10}$ ), and a similar tendency is found also in Greek numeration. Yet again there are differences. One of the two main systems of numbering in Greece (and the one that eventually predominated) was based on the alphabet, and given the presence of the digamma for 6 and of Phoenician signs for 90 and 900, it has been argued that this system must have been introduced a fair while before the first actual extant evidence for the use of such symbols on Greek inscriptions in the mid-fifth century B.C. Yet although the Greek alphabet itself is an adaptation (through intermediaries) from Phoenicia, the application of letters to numbers is *distinctively* Greek. That does not prove Greek autonomy, but it suggests a certain measure of independence: it tends to support the thesis that Egyptian, Babylonian and || Greek *logistikē* were, at least in part, three independent developments. Now the Greeks of the sixth or fifth centuries certainly *could* have learnt a great deal from Babylonian *logistikē*. Already in the second millennium B.C. the Babylonians showed considerable mastery in a whole range of arithmetical and algebraic techniques, for example in the solving of quadratic equations. Yet there is no solid evidence that *before* the Hellenistic period the Greeks did learn anything of importance from this source in this field. The superiority of Babylonian arithmetical manipulations to what we find in Greece is evidence *against* extensive influence in this area.

But what about geometry? It is after all geometry and astronomy that provide the two star cases of studies which the Greeks themselves said were developed by their Near Eastern neighbours and which they said they learned from them. There, were, in fact, two competing ideas current in Greece about the origin of geometry, in both of which it is located in Egypt. In one, the version we find in Aristotle, geometry (or rather the mathematical arts in general) originated in Egypt because the priestly class there enjoyed the leisure essential for theoretical pursuits. In the other, the version that goes back to Herodotus, *geometria* arose in response to the purely practical problems of land measurement - as the etymology of the Greek term suggested. It was from the need to measure the land before and after the Nile flooding that the study arose, the Greeks thereafter deriving their knowledge of it from the Egyptians.

In what remains of Egyptian geometry, as of Egyptian arithmetic, practical exercises bulk large. One example after another deals with practical

problems such as measuring areas or volumes; very important if you have to calculate the number of bricks you will need for a pyramid. This does not by itself rule out a theoretical interest as well, to be sure. Yet what was lacking, from both Egyptian and Babylonian geometry, *so far as we can tell*, was the notion of geometrical proof. An illustration may make this clearer. The truth of what we know as Pythagoras' theorem was undoubtedly known and used at a very early stage. On one cuneiform tablet from Babylonia dating from around 1600 B.C. there are fifteen rows of 'Pythagorean triplets', that is numbers (like 3, 4, 5) in which the squares of the first and the second equal the square of the third. Yet what is missing is evidence of any attempt to prove Pythagoras' theorem geometrically. Of course it can be proved, and was in fact proved by the Greeks, in a variety of other ways besides the traditional 'windmill' proof that figures in Euclid, *Elements* 1.47 (which is rather unlikely to have been the original method of demonstration). But what any proof must do, to be a proof at all, is to proceed deductively from certain premises to the required conclusion, and it is this conception of a geometrical demonstration that is, *so far as we know*, lacking from Egyptian and Babylonian, but highly developed in  $\parallel$  Greek, geometry. There is no need to doubt that the influence of Egyptian and Babylonian geometrical knowledge (that is the propositions known by them to be true) on the Greeks may well have been considerable. But Herodotus' thesis is, by and large, endorsed by the extant evidence. There appears to be a fundamental distinction between the general aims of Egyptian and Babylonian geometry on the one hand, and those of Greek geometry on the other, in the concentration, in the latter, on demonstration. The development of geometrical proof begins some time in the fifth century, and rapid progress is made towards the full axiomatisation of geometry into a deductive system in the fourth leading up to Euclid's *Elements* around 300 B.C. But this, in the current state of our knowledge, must be said to be a purely Greek development.

The story we have to tell in astronomy is similar, though more complex. Herodotus tells us, for example, that the *polos* and the *gnomon*, the simple sighting instruments used in Greek astronomy, were introduced into Greece from Babylonia. The author of the *Epinomis* (who may or may not be Plato) says that the first to observe the planets was a barbarian and reference is made to the peculiarly favourable atmospheric conditions for astronomical observation in Egypt and Syria. Much more clearly Aristotle mentions astronomical observations carried out by the Egyptians and Babylonians 'who have watched the stars from the remotest past and to whom we owe many incontrovertible facts about each of them'.

These testimonies establish that already in the fourth century B.C. the Greeks spoke freely of the useful astronomical knowledge that they had derived from the Egyptians and Babylonians, but the question we must ask is precisely what knowledge and from whom. The references to the Egyptians (in the *Epinomis* and Aristotle) are odd, since they hardly tally with what we

know of Egyptian astronomy. The extant direct evidence does not support the idea that the Egyptians carried out detailed observations of, for example, planetary positions before the Hellenistic period. *Either* that is simply due to the fragmentary nature of our extant evidence, *or* what the Greeks were speaking of are not original Egyptian observations so much as Egyptian knowledge of Babylonian work. Be that as it may, the chief lesson the Greeks could have learnt (and that Greek astronomers eventually did learn) from Egypt in this field was the value of the Egyptian solar calendar of 365 days and its superiority to their own chaotic lunisolar civil calendars. But although the conventional 365-day year is the system that late Greek astronomers such as Ptolemy used, it would be a rash person who would date its introduction into Greek astronomy before (say) Hipparchus in the second century B.C. Meanwhile the Greeks persisted in their use of the various, confused, non-standardised civil calendars, even though from about 430 B.C. onwards (after the work of Meton and Euctemon) the length of the solar year had been determined fairly accurately.  $\parallel$

But astronomical observation was, of course, much more the forte of the Babylonians, and extant cuneiform tablets dating from the second millennium B.C. show that the range of phenomena they were interested in was extensive. They include eclipse data and records of the appearances and disappearances of planets. In part, these periodic tables are based not on direct observation, but on computation, that is extrapolation from the data. For our purpose, however, it is enough to note that extended observations did, nevertheless, take place. But the questions we have to ask are (1) when did knowledge of these Babylonian tables permeate into the Greek world, and (2) what relevance did they have to Greek astronomy?

Part, at least of the answer to the second question can be gained from looking, once again, at late Greek astronomy, particularly Ptolemy. Ptolemy, who uses a sexagesimal system of division of degrees into minutes and seconds which is undoubtedly derived from the Babylonians, is able to cite eclipse and planetary data going back to the eighth century B.C. He takes the first year in the reign of Nabonassar, i.e. 747 B.C., as epoch, and uses several eighth- and seventh-century eclipses. It is also clear from Ptolemy that the use of Nabonassar 1 as epoch and that of Babylonian eclipse records go back to Hipparchus in the second century B.C. But if by *this* time Babylonian observations clearly provided important material for Greek theoretical astronomy, how much earlier than Hipparchus did this begin? Here we must confront the thorny problem of Thales, who is reported by Herodotus to have predicted an eclipse of the sun (in 585) to within a year – where many modern commentators have supposed that his achievement must have been based on Babylonian eclipse records. Yet that conclusion is, to say the least, premature – for two main reasons. First, at no stage was anyone, whether Greek or Babylonian, in the ancient world in a position to predict solar eclipses *visible at a particular point on the earth's surface* (though they could

say when an eclipse was ruled out and when it was not). Secondly Herodotus says merely that Thales foretold the eclipse to *within a year* (a qualification often omitted by later doxographers in their wish to represent Thales as a marvel). It looks as if the most we should attribute to him is some knowledge of the regularity of eclipses. Moreover *if* he had access to Babylonian eclipse data it is very strange that no other Greek astronomer made any use of them down to the fourth century.

It is there, in fact, in a study of the evidence for the fourth century, the time of Eudoxus and Aristotle, that our best hope of answering our question lies. Eudoxus, who was responsible for the first fairly detailed mathematical models of the movements of the sun, moon and planets, may well have derived his figures for the zodiacal and synodic periods from the Babylonians. Yet it is nowadays thought unlikely that he had access to detailed records concerning the retrograde arcs of the planets – or that he had himself carried out detailed observations of these. Simplicius suggests that  $\Pi$  records of Babylonian observations only began to reach Greece in considerable quantities *after* the conquests of Alexander. But that is not the main argument. Eudoxus' model simply fails to take account of the differences in the length and shape of the retrograde arcs, from which we may conclude that either Eudoxus was not aware of these or he chose to ignore them in his model. The evidence in Aristotle tends to confirm that the Greeks were in general satisfied with rather imprecise astronomical observations in the fourth century. First he has no precise dating system (and never dates an observation more exactly than to the archon year). Secondly he had no system of locating an event or object in the heavens with precision – no system of celestial coordinates, whether polar or ecliptic. Though Aristotle is, as I noted, evidence that *some* knowledge of Babylonian astronomical observations extending over a long period had begun to penetrate into the Greek world, we may have valid doubts both about the extent of that penetration and about the use the Greeks would have put the data to in the fourth century B.C.

'The use the Greeks would have put the data to' raises, however, another and more fundamental problem, that of the aims of the two traditions of astronomy, Greek and Babylonian. As I have said, we find detailed periodic tables relating to a variety of celestial phenomena dating back to the second millennium B.C. in Babylonia. But though we can be confident that the practice of observation began at an early period, if we ask how far those early Babylonian observers were concerned with astronomical theory, that is with geometrical models, the answer is very different. We have little or no evidence of any Babylonian attempts to construct mathematical models of the heavenly bodies until the Seleucid period. Early Babylonian astronomy, to put it briefly, was not *geometrical* or *theoretical* astronomy, as that term was understood by the Greeks, at all, but *computational*. From their periodic tables certain phenomena could be predicted (much in the way that high and

low tides can be predicted from periodic tables without any theory of the causes of tides). But what we lack is evidence of any interest in the question of explaining the movements of the planets, moon and sun in terms of a mathematical model, that is as the resultant of a combination of mathematically determined figures.

What then should our conclusions be, so far as the influence of Babylonian on Greek astronomy goes? First there is no need to doubt Herodotus' statement that sighting instruments were introduced into Greece from Babylonia. We can add that some Greek constellation configurations and the zodiac itself may have been influenced by Babylonian conceptions. Again there is no need to doubt that some knowledge of the results of Babylonian observational astronomy had begun to penetrate the Greek world before the end of the fourth century. The possibility that Eudoxus drew on those results is there, though the extent to  $\Pi$  which he did so should not be exaggerated. Yet the chief point is this: the debt of Greek astronomy to Babylonian is in the *material* on which to construct theories, not in the theories themselves or in the idea of the possibilities of such theories.

I turn finally to the last of the four areas I selected for discussion, namely medicine. Here too, as in astronomy, work has been undertaken recently that helps to define and delimit the possibilities of influence much more narrowly than before. In this case it is Egypt, not Babylonia, that is important. Babylonian medicine was, to judge from the extant remains, much more straightforwardly magical than Egyptian. So far as Egypt itself is concerned, we have a range of medical papyri dating from the second and first millennia B.C. which present an interestingly complex picture from which it is clear that Egyptian medicine was far from being just a matter of magical prayers and rituals combined with some simple empirical treatments. The famous Edwin Smith papyrus (dating from about 1600 B.C. but incorporating material from a much earlier period) is remarkable for two reasons, especially. (1) it is almost (though not quite) free from references to charms and the like, and (2) it contains a systematic and quite full description of a number of surgical cases. When we turn to the Greeks – of a far later period, to be sure – we must first emphasise the heterogeneity of what we have to call 'Greek medicine'. Apart from folk-medicine, there was a strong strain of religious or 'temple' medicine, connected with a variety of gods and heroes thought of as healers, and especially, from the fifth century on, with Aesclepius. Then too there was what we may call theoretical or rational medicine, and this in turn was itself highly heterogeneous. From as early as the sixth century B.C. we find a bewildering variety of theories put forward by different medical writers on such questions as the causes of diseases and their cures. The diversity of theories contained in the Hippocratic Corpus is very great, and we can confirm from the history of medicine in the Anonymus Londinensis papyrus that many other theories were produced by the Greeks in the fifth and fourth centuries.

Of these main overlapping strands in 'Greek medicine' it is the Hippocratic writers that concern us most from the point of view of the development of Greek science, and it has recently been suggested that many of the treatises that have been associated with Chidos especially may have been directly influenced by Egyptian medicine in two main respects. The first is in the presentation or description of disease in a systematic form, in which the title of the disease comes first, followed by an examination or description and diagnosis, followed by notes on therapy, and in which diseases are dealt with in sequence 'a capite ad calcem', starting from the head and working down the body. The second respect is in the particular importance attached to 'residues' in the body as pathogenic substances. Now in neither case can we be certain of such a direct influence. The interpretation of the Egyptian term for 'residue' is disputed. The systematic presentation of diseases does not necessarily tell for direct influence, since (1) the fit is not exact (between the Edwin Smith papyrus, for example, and the Hippocratic works in question) and (2) the sequence 'a capite ad calcem' might be one that any doctor might arrive at independently as soon as he saw the need to introduce some organisation into the account of diseases.

Nevertheless although the hypothesis of direct influence may be said to be 'not proven', a useful general lesson can be learned from the comparison between Greek and Egyptian medicine. The importance of medicine in the early development of science has often been underestimated in comparison with the more impressive results obtained in, for example, astronomy. Yet medicine was one of the chief battlefields on which the attempt to distinguish the 'rational' and the 'magical' was fought. Here too – as we have found so often elsewhere in our inquiry – there is an important distinction between the Greeks and their Near Eastern predecessors, in that Greek medical literature includes, in such works as *On the Sacred Disease*, *direct and explicit* attacks on the use of magical practices and beliefs. But if *that* cannot be paralleled in Egypt, the concentration on direct observables (on empirical factors) in the Edwin Smith papyrus is suggestive. In folk medicine, and primitive medicine in the twentieth century, what we distinguish as 'empirical' and 'magical' beliefs and practices often coexist – without any clear distinction being drawn between them. But their very coexistence can provide occasions for reflection on their different status. Explicit attacks on 'magic' as such are, I said, a Greek phenomenon. But the Egyptian evidence shows very clearly how even before 'magic' as such became an issue – as it did in Greece – the emphasis, in practice, can be very strongly on the empirical end in the empirical-magical spectrum.

If I may claim your indulgence for a few minutes longer, I should like to try to draw some of the threads of my argument together. If we look at the eastern Mediterranean world *after the conquests of Alexander*, the situation – thanks largely to those conquests – was one where the communication and exchange of ideas were *comparatively* easy. Many of the barriers between

Greeks and non-Greeks, and among different non-Greeks, began to be eroded, even if they were far from being removed entirely. There is a symbolic significance in the fact that Alexandria itself, one of the main centres of Greek scientific activity from the third century B.C. on, was a Greek foundation in Egypt, although, to be sure, one should guard against attaching *too* much importance to that fact. The idea that Herophilus and Erasistratus learned how to dissect from Egyptian mummifiers is just one gross exaggeration among many perpetrated by those who underestimate the gulf that still existed between the Greek community in Alexandria and the indigenous Egyptian population. Yet in astronomy, by the time of Hipparchus, the results of Babylonian observational work were available to the Greeks, and the importance of that confluence of two traditions would be hard to exaggerate.

But *before* the Hellenistic period, if we go back to the sixth or fifth centuries B.C., the situation is a complex one. There was undoubtedly some exchange of ideas, some interpenetration, between the three main cultures. Yet there are also important differences between them, plenty of signs of independent developments in such matters as writing and numerical notation, on occasion positive barriers to, or failures of, communication (as when Babylonian skill in handling quadratic equations appears to have been confined to Babylonia).

The problem I began with was that of the origins of philosophy and science. One can argue, I think one must argue, that philosophical inquiry was a distinctive Greek invention. Philosophy took over many ideas, beliefs and attitudes from both religion and mythology, and both Greek and non-Greek religion and myths are involved. Yet in so far as the philosopher is committed to justifying his position with argument and evidence, his aims and methods are different from those of either the priest or the prophet or the mythologist. If we should recognise the debt of Greek philosophy to the cosmological ideas implicit in Greek and non-Greek religion and myths, we must also recognise the fundamental difference between the aims of philosophy and those of mythology.

In science, as I said, a far more direct comparison is possible between Greek and pre-Greek contributions. Here it is not a matter of trying to compare Greek philosophy with Near Eastern mythology, but of comparing what we rightly call Babylonian *astronomy*, Egyptian *medicine* and so on, with their Greek counterparts. Here too there are (I argued) certain differences in the aims, in the questions asked, and in the methods used to resolve them or justify the answers, between Greek and pre-Greek inquiries. Yet the nature of the transition – and the nature of the debt – differ from one field to another. If the Greeks were (as they appear to have been) the first to develop the notion of geometrical demonstration, to seek astronomical models to explain the movements of the heavenly bodies, to distinguish explicitly between what they called magic and what they called the 'art' of

medicine, they were, of course, not the first to discover many geometrical truths, to undertake sustained observations of the stars, to attempt to record the symptoms of diseases. Here it is too easy arbitrarily to decide on one simple criterion that can be used to mark out 'science' from 'non-science'. Although sometimes the distinctive conceptual breakthrough (the realisation of a problem, the asking of a new kind of question) is the important factor, in other cases one must accept a certain *gradualism* in the emergence of the science. The challenge of the subject I have been discussing is || to do justice to those complexities. We are still in the dark on many problems, and we can expect to know more as time goes on and research continues. But as for some aspects of the question as they appear to one observer today, I have tried to put the issues before you, and I hope that, ancient as the debate is, you will agree to its continuing interest.

## IN: METAGOS AND ROBENS IN GREEK SCIENCE