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GREEK SCIENCE

BY

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PREFACE

The subject of Greek science is vast. One could spend a lifetime reading and thinking about just what Aristotle wrote, and Aristotle was only one of a number of prolific authors. Surviving authors are only contributors to the subject on which they wrote, having predecessors, contemporaries, and successors. It is simply not possible to gather, absorb, and evaluate all of Greek science, and all of the research of all scholars of Greek science.

There are many excellent existing books about aspects of Greek science, which typically discuss the great men and the great discoveries, or trace, with perfect hindsight, the paths of development in a subject. A brief recitation of the same material is hardly needed, especially when space is at such a premium. Instead, what I hope to convey is a sense of the range and scope of the ancient scientific material which exists. I will not spend all of my time on the great and good, so that I can make room for some of the lesser lights. Not all Greek scientists were geniuses and not all of their ideas were brilliant. But these other works are nevertheless fascinating, and deserve to be better known. They convey more 'ordinary' science, the ancient equivalent of the TV nature programme or the coffee-table science book, which then as now was more common, and which then as now penetrated popular culture.

Consequently, I see my primary purpose in this survey as being to introduce modern readers to the ancient Greek literature which is classified loosely as science. A great deal survives, from which I shall select to give a taster of the ancient practice and practitioners of science. I hope these will be found sufficiently interesting to the reader to inspire her or him to go and read some ancient scientific text in full – for its historical value, if not for its scientific content. I also wish to draw attention to scientific matters in authors of more popular genres. My secondary purpose is to indicate the range and extent of the modern literature on ancient science. It is not from lack of interest or disapproval that I have omitted numerous ancient and modern works from this survey, but my inability to read everything relevant, and a lack of space to discuss more than a fraction of what I have read. The 'Further Reading' section at the end of each chapter is intended to guide the reader to more literature and bibliographies, old and new.

I will not discuss the philosophy of science or the philosophy of the

history of science, but it is appropriate here to indicate my position on some contentious matters within those fields. I believe in a real world 'out there'; that we can perceive that world through our senses; that we do not perceive reality simply, directly, and immediately, but that our perception is filtered by our ideas and beliefs; that systems of ideas and beliefs change over time and space, so that different filters operate in different times and places. I believe that modern understandings of the real world can help us comprehend ancient understandings, as much as if not more than they may hinder us.[1] I believe that science, like every other human activity, does not take place in a vacuum, but is influenced by the social, economic, political, religious, and every other type of cultural system operating in the place and time in which the science is undertaken.

For the purpose of this survey I have focused on works in English, i.e. ancient texts with good English translations, and secondary literature in English. But it should be noted that English speakers are less well served than some others, especially in the area of the absolute essential to study: the texts.[2] Budé have an excellent range of ancient scientific texts with facing French translations.[3] Teubner also have a good range of texts, some with facing German translations (Latin in older editions). The Loeb Library is rather disappointing when it comes to the scientific tradition: the texts which have been done have been done well, on the whole,[4] but the coverage is patchy. You will not find in Loeb's library Archimedes, Apollonios, Diophantos or Euclid, bar a few short highlights selected for the two volumes of *Greek Mathematical Works*;[5] you will not find Ptolemy's *Astronomy*,[6] *Geography*, *Optics*, *Harmonics*,

[1] On this see Pickstone 1995.

[2] We might compare the 104 books by Galen which Hunayn ibn Ishaq translated into Syriac in the C9 A.D. (Benoît and Micheau 1995, 201) with the 30-odd available in English.

[3] They include, for example, Arrian's *Periplous of the Euxine*, Diophantos' *Arithmetic*, and the Leiden and Stockholm alchemical texts.

[4] Some editions suffer lacunae deliberately introduced in response to cultural factors prevailing when the work was published (often, a long time ago), such as Hort's omission of a section of Theophrastos' *History of Plants* 9.18, which mentions male genitalia, contraceptive drugs (for men as well as women), aphrodisiacs (including what is reputed to be an ancient equivalent of Viagra), and abortion.

[5] Edited and translated by Thomas 1939–41. These volumes are excellent as far as they go; the problem is that they have just bits of different works. Consider a hypothetical analogy: what sort of understanding could one achieve of, say, Greek tragedy, if one depended on two volumes of *Greek Tragic Works* featuring 'the best' speeches in this or that play by Aiskhulos, Sophokles, and Euripides?

[6] Better known by the title the *Almagest*, formed from the Arabic definite article *al-* and Greek *megiste*, and meaning 'The Greatest'. It dominated astronomical thinking for over a millennium. It has been translated by Toomer and published by Duckworth 1984.

Handy Tables, *Hypotheses*, *Phaseis*, *Analemma* or *Simple Sphere*, but only his *Astrology*;[7] you will find only one volume of the hundreds written by the prolific Galen.[8] You will find Theophrastos' *Characters*, *Causes of Plants* and *History of Plants*, with *On Weather Signs* and *On Odours* tucked on to the end of the second volume of the latter; you will not find other works of his, such as *On Fire*, *On Fish*, *On the Senses*, and *On Stones*. (Things could be worse: Penguin only have the *Characters*, which is his least important work.) For many of these omissions, someone somewhere has edited the text and published an English translation, but they can be difficult to find, and they can be very old.[9] For the convenience of the reader I have quoted the Loeb translation wherever possible,[10] and I thank Harvard University Press for permission so to do.

A considerable debt of gratitude is owed to students at the University of Wales Swansea and the University of Wales Lampeter who have taken my courses on ancient science and technology since 1991. Their enthusiasm for the subject has been a constant stimulus to me to develop and promote its study. I am also indebted to my husband, John Tucker, without whose help and encouragement I would probably never have got to grips with geometry, and hence astronomy and mathematical geography. He also read every chapter several times and improved the structure and clarity of the text enormously. The Institute for the History of Science and the University Library (Carolina Rediviva) at the University of Uppsala kindly allowed me to use their facilities in August 1998. It is also a pleasure to thank Ian McAuslan for his tremendous help and advice at various stages of this project.

T. E. Rihll

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[7] Known by the title *Tetrabiblos*, 'Four Books'.

[8] *On the Natural Faculties*, ed. and trans. by Brock, 1916. *Galen: Selected Works* by Singer, published by Oxford (World's Classics Series) 1997, contains 15 treatises in translation, with a good introduction.

[9] I'm thinking here particularly of Dioscorides, published by Gunther in 1933 but actually Goodyer's translation from 1655; it is not easily recognizable as English. Scarborough and Nutton have done a recent edition, translation, and commentary of the Preface to Dioscorides' *Materia Medica* in *Trans. and Studies of the College of Physicians of Philadelphia* n.s. 4 (1982), 187–227. The Preface consumes 3 printed pages; the commentary consumes 30. This gives some idea of the work which can be involved in the explication of an ancient scientific text. The whole text was done into German in 1902 by Berendes.

[10] The full catalogue is on the Internet at
http://www.hup.harvard.edu/Web_Loeb.catalog.am.html

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NOTE ON NAMES AND CITATIONS

It is impossible to be consistent in the rendition of Greek names. Some are well known in Latinized form, but there is no consistency even among these, so we have Solon but not Platon, Themistocles but not Aristoteles. Pedantry leads to unfamiliar spellings whichever principle or tradition one follows. There are four standard letter substitutions which I have found typically lead students into errors of pronunciation, and so I try to avoid them: I normally use 'k' and 'kh' (not c and ch) for κ and χ, 'i' (not e) for ι and 'u' (not y) for υ. Nevertheless, you will still find here Pythagoras not Puthagoras, Euclid not Eukleides, and all that is usually required to turn an unfamiliar name into a familiar one is a little flexibility over these substitutions and final 'n'.

To save a lot of space in the text and notes I have used the 'Harvard system' for modern works e.g. Lloyd 1995. Full details will be found in the Bibliography.

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TO THE SCIENTIFICALLY FAINT-HEARTED READER

Understanding what is going on in most of Greek science is well within the competence of any intelligent person, as it was in antiquity. Take heart! If you read an ancient scientific text and feel, not that you are out of your depth scientifically, but more or less *bewildered* by the contents, then you are probably reading it through modern spectacles, so to speak. Assume always that the ancient author makes sense: what he wrote was considered sensible by enough people over enough centuries – more than a thousand years in some cases – for that text to have been repeatedly copied and thus survive for us to read now. The task then is to discover in what sense he makes sense. As Klein put it with respect to mathematics, 'our task consists precisely in bringing the content of Greek mathematics to light not by externally transposing it into another mode of presentation but rather by comprehending it in the one way which seemed comprehensible to the Greeks'.[1] This search for sense can apply to the structure of a work as well as its contents: our task in that case is to recognize the principle of organization at work in what otherwise appears to be a set of more or less disorganized notes, as for example in the cases of Aristotle's *History of Animals*, Theophrastos' *History of Plants*, or Dioskorides' *Herbal.*

Not knowing much modern science can be an advantage, for then you do not have to unlearn what you have been taught in order to comprehend ancient science. The unscientifically-trained modern reader can approach e.g. Aristotle with an eye which sees the world perhaps more as he saw it. Even the partially scientifically trained reader may side with the ancients on some issues, despite knowing that they were wrong. And if you never stopped to consider some of the things which these ancient scientists consider, then they may fill you with wonderment, instead of puzzlement, or worse – following a well-established pattern of ancient Greek attitudes to rival theories – scorn.

Likewise, try not to jump to conclusions over 'the obvious'. Consider the following example. Given the naturalness and commonness of pregnancy, 'it's obvious' that pregnancy lasts nine months. Obvious, because we naturally assume that a woman knows when she's pregnant,

[1] Klein 1968, reprinted by Dover 1992, p. 127.

because, apart from 'feelings' or other intangibles, her periods stop. But this assumption is false, because sometimes they don't (with no ill effect on the embryo, *contra* Nigidius *apud* Pliny *NH* 7.66). It is not unusual for periods to occur for the next month or two, so that a woman can be three months pregnant before she realizes it, and light periods can continue even beyond that. These days modern technology can establish beyond doubt that she is several months, and not one month, pregnant. The ancients, needless to say, had no such technology, so relied on the cessation of periods to determine the start of pregnancy. So it was not obvious to them how long pregnancy lasted in women.[2] Thus when ancient paediatricians are concerned with 'the eight-month child' and 'the seven-month child' (e.g. Hippocratic treatises on the same), do not assume that these are premature babies. The (at first sight surprising) high survival rate expected for 'the seven-month child' is to be explained by the fact that some, if not most of them, were not premature at all, but were carried full term.

For scholars and scientists there are several approaches to the subject. Some material is so technical and complex that only a professional in that field today could understand what the ancient exponent was talking about – take Archimedes' mathematics, as an example. He was one of the most brilliant mathematicians of all time, and with the best will in the world, most of us are not going to be able to understand him, however much we might like to, and however hard we try. Understanding Archimedes therefore depends on professional mathematicians working their way through his corpus. Unless they have Greek, they in turn depend on classicists translating the text. But translating a text is difficult if you do not understand what the text means – and understanding what Archimedes' texts mean requires a mathematician![3] In previous centuries and the beginning of this there were more polymaths around, who could handle both requirements,[4] hence the age of some editions of

[2] Aristotle *HA* 584a35–b1 comments on the difference in this regard between humans (variable 7–11 months) and all other animals (invariable by species); see also [Aristotle] *Problems* 10.41. An inscription from the healing sanctuary of Asklepios at Epidaurus records Cleo's five-year long pregnancy, *IG* 4.951. See also Pliny *NH* 7.40 on a Roman legal case, where the judge knew of no good cause to deny the possibility of a 13-month pregnancy, and so awarded a disputed estate to the child of a widow of that time's standing.

[3] The problem is particularly acute in mathematics; see chapter 3 below.

[4] e.g. Thompson on natural history, birds and fishes in particular; Heiberg, Heath, and Thomas on Greek maths; Bailey on the chemical parts of Pliny's *Natural History*; and Bennet Woodcroft, a Professor of Machinery, who became tired of waiting for some professional classicist somewhere to do Hero's *Pneumatics*, and commissioned a classicist (J. Greenwood) to translate it (1851). It is *still* the only English translation of that work (Hall reprinted this with an introduction in 1971), and the source of almost all illustrations of Hero's machines, which are published widely.

scientific texts and subjects. Some subjects have been tackled by a team, a classicist to give a 'raw' translation of the words, and a specialist in the relevant area to understand their meaning, and thus together to produce a correct translation, for example, the E. R. Caley (chemist) and J. F. C. Richards (classicist) partnership[5] for Theophrastos' *On Stones*; O. Pederson (historian of science) and M. Pihl (physicist) for *Early Physics and Astronomy*; M. R. Cohen (philosopher) and I. E. Drabkin (classicist) for *Sourcebook in Greek Science*; and recently the Pliny translation group,[6] but this is rare.[7] More commonly the classicist consults scientific colleagues on specific points of difficulty,[8] but then only the texts which interest the classicists get done.

Once the text, a technically as well as linguistically accurate modern translation, and a commentary to explain the technical matters are done, the next task is to establish the historical context of the text. This area desperately needs attention by ancient historians. Few have ventured here and it is a very underdeveloped area. Hence the current historically-abstract, philologically or technically dominated state of the literature on many ancient scientific texts. As each stage progresses, it feeds back towards the text, modifying the interpretations and understanding of it.[9] Thus there is a role and a need for 'ordinary' historians in the study of the history of Greek science, which is a land of opportunity for adventurous scholars.

[5] Another classicist, S. H. Weber, and a member of the Columbia University School of Mines, T. T. Read, were also involved in early stages of production of this book.

[6] On which see Rottländer 1986. The team are translating Pliny into German.

[7] Heilbron 1996 argues that it has almost become a necessity for the history of science to be tackled by teams of scholars, scientists, and support staff in IT etc. This is the published version of the opening address of the Max Planck Institute for the History of Science in Berlin, March 1995. It remains to be seen if, and if so how, this programmatic statement is put into practice.

[8] For example, Toynbee consulted a vet (R. Walker) for his *Animals in Roman Life and Art* 1973; Walker then contributed to the book an appendix on Roman veterinary medicine, pp. 303–43.

[9] For example, proper attention to the historical information contained in one of Galen's works, as well as to the MS tradition, the style, and the medical content, allowed Nutton 1997 to demonstrate conclusively that Galen died not in 199 (as traditionally believed, on the basis of an entry in the Suda), but after 204, and possibly as late as 207. An early stage of the whole process may be seen in the area of the classical tradition in Islamic sources, which are now beginning to appear in modern European language translations. For example, Saïd al-Andalusi's *The Catalogue of Nations* is now available in English. The scholars who edited and translated the text are specialists in medieval Arabic, whose knowledge of classical scientific texts is limited (but my knowledge of medieval Arabic is non-existent) and whose notes to the text are correspondingly weak. But now that they have translated the text from Arabic, many others can access the text and enlarge our general understanding of it. The Arabs were not interested in Greek or Latin literature, but translated and preserved every ancient scientific treatise they could find.