

madness, during which he mutilated himself; but this will not explain *ingrati genitoribus*. The former moral explanation must have been more prominent in his mind."⁷

Must it be so? If *et* is taken as a true co-ordinate, the two clauses are parallel and two groups are under discussion. The first, "numen qui violarint / matris," refers to Attis and the legend surrounding him, whose story may well have been vividly known to contemporaries from Catullus' tour de force. He typifies resistance and defiance of the divine will; self-mutilation occurred in a fit of madness and is followed by regret: "rabie fera carens dum breve tempus animus est. / egone a mea remota haec ferar in nemora domo? / patria, bonis, amicis, genitoribus abero?" (Cat. 63, 57-59). The second group consists of those

who consciously and willingly mutilate themselves to serve the goddess; they have thus brought their family line to an end (how serious a matter this was to the Romans is well known, and is underscored by the frequency of adoption among families of equal social status). Their parents had given them birth and had looked forward to the continuation of the family; it is in this regard that the *galli* are ungrateful to their parents. Not only are both groups incapable of siring children, but both are deemed unworthy of doing so, even if they could. But the guilt of the latter group is the greater, because divine compulsion was absent.⁸

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7. Violation of *pietas* is the view of J. Perret, "Le 'Mythe de Cybèle' (Lucrèce, II, 600-660)," *REL*, XIII (1935), 340: "Dans le cortège, ces suivants humiliés portant les stigmates de leur cruelle mutilation représentent pour le poète les impies violateurs de toute piété filiale." D. West, *The Imagery and Poetry of Lucretius* (Edinburgh, 1969), pp. 106-107, interprets as follows: "The offence as he words it, is that they have violated the divinity of their mother and been found guilty of ingratitude towards their parents . . . In *matris* and

genitoribus in 615 Lucretius is insisting that the offence is against a parent in order to assimilate the offence to the punishment. Such people have offended against their parent and been castrated to show that ungrateful children don't deserve to have children of their own."

8. Thanks are due to Professors Joseph M. Conant and Richard W. Minadeo for helpful comment and criticism, but they do not share responsibility for the views presented.

ANAXAGORAS ON THE SIZE OF THE SUN¹

In 1923 Erich Frank argued that Anaxagoras discovered the mathematical basis of the laws of perspective and that he applied these laws to the shadows cast by the heavenly bodies to explain the workings of eclipses.² This has not been universally accepted; G. Sarton, for example, accepts Vitruvius' testimony, but assumes that Anaxagoras (like Agatharchus, whom Vitruvius also mentions) was interested in perspective "for theatrical purposes";³ and J. Burnet discounts Vitruvius' account as "most improbable."⁴ Frank's position can be strengthened, I believe, if it can be shown that

Anaxagoras' estimate that the sun is larger than the Peloponnese⁵ is not merely a guess on his part, but is as seriously considered as any mathematical statement of the form $x > a$; and that this estimate derives from his understanding of perspective and eclipses.

If Anaxagoras was ignorant of the distance from earth to moon and from earth to sun, and of the dimensions of the moon (as he must have been), what evidence did he have that enabled him to estimate the size of the sun as he did? He knew (1) that the sun is further away from the earth than the moon,⁶

1. This note, in an earlier draft, has benefited from a reading by M. S. Freedman.

2. E. Frank, *Plato und die sogenannten Pythagoreer* (Halle, 1923), pp. 20-23. Vitruvius 7. pr. 11 (DK 59 A 39) is our source for Anaxagoras' work on perspective. For his work on eclipses, cf. Hippolyt. 1. 8. 7, 9, 10 (A 42); Plut. *Nicias* 23 (A 18); Aët. 29. 6. 7 (A 77).

3. G. Sarton, *Introduction to the History of Science* (Baltimore, 1927), I, 86.

4. J. Burnet, *Early Greek Philosophy*⁴ (London, 1930), p. 257. Cf. further D. Lanza, *Anaxagora: Testimonianze e Frammenti* (Florence, 1966), p. 44.

5. Diog. Laert. 1. 8 (A 1), Hippolyt. 1. 8. 8 (A 42), Aët. 2. 21. 3 (A 72), Theodoretus 4. 22.

6. This is necessary for a correct understanding of solar eclipses, and that Anaxagoras believed this is stated by Hippolyt. 1. 8. 7.

and (2) that the sun is larger than the moon.⁷ With this knowledge, he could hope to learn something further of the size of the sun or moon from an investigation of a total eclipse of the sun, for the area of total darkness is the length of the small side of the truncated cone of the shadow cast by the moon.⁸ The eclipse could be represented in a diagram, where lines are drawn from the outer edge of the sun tangent to the moon to the earth.⁹ If he could estimate the width of the umbra, he would have the minimum size of the sun (and moon).

The only possible subject of Anaxagoras' investigation is the eclipse of April 30, 463 B.C., which passed through Greece in an east-west direction.¹⁰ He would, however, be unaware that the area covered by the umbra can vary from zero to a maximum of 180 miles, depending on the distances from the earth to the moon and from the earth to the sun.

7. This follows from (1) and from the fact that the sun *appears* to be the same size as the moon, which, his knowledge of perspective would tell him, could only be true if it is in fact larger.

8. For the sake of simplicity, I ignore the fact that more often than not the shadow cast on the earth is elliptical.

9. It is inconceivable that Anaxagoras could have taught himself the laws of perspective without the use of diagrams. I therefore take Plut. *Nicias* 23 *ἐς γραφὴν καταθέμενος* to refer to such a diagram, not merely as "in writing" (W. K. C. Guthrie, *A History of Greek Philosophy*, II [Cambridge, 1965], 270).

10. This is often said to be the eclipse mentioned by Pind. *Paeon* 9. 3 (Snell), but cf. Robert R. Newton, *Ancient Astronomical Observations and the Accelerations of the Earth and Moon* (Baltimore, 1970), pp. 99 f. The eclipse of 478 B.C. was

As far as can be determined from the data supplied by Oppolzer, the umbra for the eclipse of 463 B.C. was 133 miles.¹¹ Anaxagoras may have reached a similar figure by questioning as many people as he could to ascertain who saw a full and who a partial eclipse. One of the panhellenic festivals would facilitate the taking of such a poll. 133 miles is roughly the distance from Cyllene to Troizen or from Elis to Boiai. Even if we allow for error (on our part and on Anaxagoras'), we may still conclude that, if he had carried on the investigation outlined above, the safest observation a cautious observer could make concerning the size of the sun is that it is larger than the Peloponnese.¹²

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annular (i.e., there would be no umbra); the next total eclipse to pass through Greece after 463 B.C. was in 402 B.C.; cf. Th. R. von Oppolzer, *Canon der Finsternisse* (Vienna, 1887; repr. New York, 1962), Taf. 35–39.

11. I am grateful to Raynor L. Duncombe of the U.S. Naval Academy for providing this figure. Unfortunately, factors introduced by the secular acceleration of the moon produce some error in the figure; cf. D. H. Menzel and O. Gingrich, preface to the reprint of Oppolzer, p. v. Newton, *op. cit.*, is an attempt to determine this acceleration.

12. Oppolzer's plate No. 36 has the path of the eclipse passing just north of the Gulf of Corinth. If astronomers, after accounting for the error introduced by the secular acceleration of the moon, were to find that the path passed over the Peloponnese, so much the better for my argument.