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(b.Sidon, ca. 150 B.C.; *d*. Athens, ca. 70 B.C.)

philosophy, mathematics, logic.

According to ancient tradition, Zeno of Sidon was a very prolific writer who discussed theory of knowledge, logic, various aspects of ancient atomic theory, the fundamental differences of the sexes (from which it follows that they have different diseases), problems of Epicurean ethics, literary criticism, style, oratory, poetry, and mathematics. Very little is known of the contents of these writings except those on mathematics and logic, which are of great interest.

Epicurus had been a very severe critic of mathematics as a science : but what he said about it is very superficial and shows that he did not understand what mathematics is. This is not at all the case with Zeno's criticism of Euclid's axiomatics. In his commentary on Euclid, Proclus says that Zeno attacked the first theorem of the *Elements* (the construction of an equilateral triangle) on the ground that it is valid only if one assumes that two straight lines cannot have more than one point in common, and that Euclid has not set this down as an axiom. On the same ground he attacked Euclid's fourth postulate, which asserts the equality of all right angles, observing that it presupposes the construction of a right angle, which is not given until I, 11. In addition, Proclus and Sextus Empiri-cus mention several criticisms of Euclid that they attribute to an unnamed Epicurean and that are similar to Zeno's criticisms: for instance, that there is no axiom establishing the infinite divisibility of curves, which is connected with a discussion of various consequences following from the assumption that curves are not infinitely divisible but, rather, are composed of the smallest units of indivisible lines. There is also a criticism anticipating Schopenhauer's of Euclid's method of superimposition, by which he proves the first theorem of congruence and a few other theorems : namely, that only matter can be moved in space.

On the basis of these criticisms of Euclid's ax-iomatics, **E. M.** Bruins has claimed that Zeno of Sidon was the first to discover the possibility of non-Euclidean geometry. This claim appears exaggerated, since there is not the slightest tradition indicating that Zeno elaborated his criticism in such a way as to show positively how a non-Euclidean geometrical system could be built up. Zeno's criticisms of Euclid are pertinent, however, and if any of the ancient philosophers and mathematicians who tried to refute them had been able to grasp their full implications, the development of mathematics might have taken a different turn.

Lengthy fragments of a treatise by the Epicurean philosopher Philodemus of Gadara have been found on a papyrus from Herculaneum (no. 1065), and most of those preserved contain a report on a controversy between Zeno and contemporary Stoics over the foundations of knowledge. In this dispute Zeno defended the old Epicurean doctrine that all human knowledge is derived exclusively from experience. What makes it interesting, however is that he bases his defense on a theory that he calls "transition according to similarity" (μετάβασις καθ̕ ὁμοιότητα) or "transition from the apparent to the not apparent" (μετάβασις α ἀπο̇τω̄ν Φαινομένων ἐς τά άΦανη̄), but that is essentially an anticipation of John Stuart Mill's theory of induction.

In contrast to Aristotle's theory of induction, according to which the most certain kind of induction is that in which one case is sufficient to make it evident that the same must be true in all similar cases, and in opposition to the Stoic doctrine that no number of cases ever permits the conclusion that the same must be true in all cases, Zeno insisted that all knowledge is fundamentally derived by inference to all cases from a great many cases without observed counter-instance. He carried this principle to the extreme by asserting that the knowledge that the square with a side of length 4 is the only square in which the sum of the length of the sides (16) is equal to the contents (4 X 4 = 16) was derived from measuring innumerable squares, although here it is evident that the result-insofar as it is correct, one-dimensional measures being equated with two-dimensional measures-can be derived from a simple deduction and that nobody will be so foolish as to "verify" it in innumerable squares. The recent proof by computers that the principle is not altogether applicable to mathematics and number theory shows that certain theorems of Pólya's that had been considered universally valid because they had been proved up to very high numbers were not valid beyond higher numbers unreachable by human calculation.

The details of the controversy between Zeno and the Stoics is extremely interesting because sometimes the positions become curiously reversed, and because it provides a kind of phenomen-ology of induction going beyond most modern works.

BIBLIOGRAPHY

I. Original Works. Extracts of Zeno's lectures are in T. Gomperz, *Herkulanische Studien*, **I** (Leipzig, 1865), 24–27; and **P. H.** and E. A. de Lacy, eds., *Philodemos: On Methods of lrtference,* which is Philological Monographs of the American Philological Association, no. 10 (Philadelphia, 1941)-see index. (Pp. 22–66, columns la, I-XIX, 4, are mostly extracts from Zeno's lectures, but it is not certain how far they are literal.)

II. Secondary Literature. See Ludger Adam. "Das Wahrheits- und Hypothesenproblem bei Demokrit, Epikur und Zeno, dem Epikureer" (**Ph.D.** diss., Göttingen, 1947); E. M. Bruins, *La géométrie non-euclidienne dans l'antiyuitéM*, Publications de l'Université de l'Université Paris, D121 (Paris, 1967): and G. Vlastos. "Zeno of Sidon as a Critic of Euclid," in *The Classical Tradition: Literary and Historical Studies in Honor of Harry Caplan* (New York, 1966), 148–159.

On problems arising in connection with Zeno's theory of induction, see C. B. Haselgrove, "A Disproof of a Conjecture of Pólya," in *Mathenxaica*.**5** (1958), 141; K. von Fritz, "Die ἐπαγωγή bei Aristoteles," in *SitzungSherichte der Baverischen Akadentie der Wissenschaften zu Miincüh en*. Phil.-hist. Kl. (1964), no. 3, 40 ff., 62 ff.; and R. Queneau, "Conjectures fausses en théorie des nombres," in *Mélanges Koyré*, **I** (Paris, 1964), 475 ff.

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