DISCUSSION AND CORRESPONDENCE

ARCHIMEDES AND TRIGONOMETRY

ARCHIMEDES (287–212 B. C.) is commonly regarded as the greatest mathematician of antiquity, but it is only recently that he has been credited by modern writers on the history of mathematics with fundamental developments in trigonometry. Our text-books on this subject usually refer to the Greek astronomer, Hipparchus, who lived about a century later than Archimedes, as the founder of trigonometry. It should therefore be of wide interest to note here that recent discoveries relating to the works of Archimedes, especially to one devoted to the heptagon, seem to establish the fact that we now have more substantial reasons for regarding Archimedes as the founder of trigonometry than we have for giving this credit to Hipparchus. In particular, Archimedes seems to have known rules which are equivalent to our common formulas for the sine and the cosine of the sum and the difference of two angles.

In a recent number of the *Archiv für Geschichte der Mathematik, der Naturwissenschaften und der Technik,* Volume 10, page 432, the well-known German writer on the history of elementary mathematics, Johannes Tropfke, discusses at considerable length some of the necessary modifications relating to the history of trigonometry which result from the recent discoveries as regards the work of Archimedes. He points out, in particular, that Archimedes knew the rule which is now commonly expressed by the following formula:

$$\sin\frac{A}{2}=\sqrt{\frac{1-\cos A}{2}}$$

The ancient Hindu and Arabian writers regarded this rule as one of the most important ones of trigonometry, and it has been assumed heretofore that it was probably due to Ptolemy, who used it without referring to its earlier use by others. It is very interesting to note therefore that it now seems to be due to Archimedes, who lived about four hundred years earlier than Ptolemy. The recent discoveries to which we have referred tend also to give additional support to the view that the so-called Heron formula for the area of a plane triangle in terms of its sides is due to Archimedes, and this constitutes another substantial reason for regarding him as the founder of trigonometry.

It should be added that these discoveries relate to Arabian translations and to references found in Arabian works, and it is well known that many such references are unreliable. In the present instance there are, however, many indirect evidences which tend to support these references. At any rate it is interesting to know that discoveries which promise so much for the history of trigonometry have recently been made, especially since the work of writers who preceded Archimedes seems to show clearly that the fundamental rules to which we referred above could not have been known in their times, and hence it does not seem likely that they could have been known long before the times of Archimedes. Such discoveries also tend to emphasize the important fact that the rapid advances which are being made in the history of science are apt to affect our views as regards some of the oldest and most fundamental developments.

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REPRODUCTION RATE IN WILD RATS

As a contribution to the subject dealt with by Dr. Donaldson in SCIENCE for March 20, 1925, "Control of Rat Population," we submit the following:

In 1922 the board of health of New Bedford, Mass., at the suggestion of the U. S. Public Health Service, undertook a rodent survey of the town which was carried on for a period of about two years. Two trappers were employed to trap rats in the business portion of the city and along the water front. The rats were brought to the laboratory of the board of health and examined for lesions of plague by one of us (C. S. S.). Since the whole number examined was small (about 6,000) it was possible to extend the examination beyond the mere search for plague. Careful observations of pregnancy in the female and of the number of fetuses were recorded. Of the total number of female rats examined, seven per cent. were found to be pregnant. This percentage varied little from season to season.

The female rat becomes sexually mature at about three months of age and remains fertile until about twenty months of age. The average life-span of the rat is about three years. Thus the period of fertility is approximately one half of the whole life-span. If the rats which were trapped were equally distributed as to age, approximately one half of the females brought to the laboratory would be fertile. The period of gestation in the rat is about twenty-one days. Pregnancy is grossly visible in the exposed uterus for about sixteen days. If the female rats which were trapped were all reproducing at the rate of one litter per year and there was a purely random distribution as above-mentioned, there would be about one chance in forty-five ($16/365 \times \frac{1}{2}$) of finding pregnancy in any female, that is, about 2 per cent. of the females would be pregnant. The fact that 7 per cent. of the rats were found to be pregnant seems to indicate that