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also known as **Ajima Chokuyen**

(common name, **Manzo** ; pen name, **Nanzan**) (*b*. Shiba, Edo [now Tokyo], Japan, *ca*. 1732; *d*. Shiba, 1798)

mathematics.

Ajima was born at the official residence of the Shinjo family, and was later stationed in Edo as a retainer of that clan. He remained there until his death, and is buried in the Jorin-ji Temple, Mita, Tokyo.

Ajima first studied mathematics under Masatada Irie of the Nakanishi school, and later he studied both mathematics and astronomy under Nushizumi Yamaji, who initiated him into the secret mathematical principles of the Seki school. He was apparently over thirty when he began his studies with Yamaji; his career before then (save for his studies with Masatada) is largely a matter of conjecture. Ajima wrote several works on astronomy soon after becoming Yamaji's pupil; it is presumed that during this time he was also engaged in helping his master to compile an almanac. After Yamaji's death, Ajima began to write on mathematics.

In the traditional succession of the Seki school, Ajima is in the fourth generation of masters. None of his books were published in his lifetime; they existed solely as copies handwritten by his students, perhaps because of the esoteric nature of the discipline. Most of the essential points of his work are summarized in his *Fukyu sampo*, a book that Ajima intended as an emendation of Sadasuke Fujita's *Seiyo sampo*, which was then a popular textbook. His pupil Makoto Kusawa wrote a preface to this book in 1799, a year after Ajima's death; although Kusawa planned to publish the work, he did not do so. Kusawa succeeded Ajima as a master of the Seki school. Masatoda Baba and Hiroyasu Sakabe were also students of Ajima; as did Kusawa, they had their own pupils, many of whom became first-rate mathematicians and continued the tradition of the Seki school until the Meiji restoration (an arithmetic book in the European style was published in Japan in 1856, and marked the end of the native forms of mathematics).

The mathematics originated by Takakazu Seki was refined by his successive pupils and tentatively completed and systematized by Yoshisuke Matsunaga and Yoriyuki Arima. who was the first to publish it. Upon this base Ajima began to develop a new mathematics; his works reflect an innovative trend toward geometry within a tradition that was basically algebraic and numerical in approach.

This trend is exemplified in the development of *yenri*, a method for determining the area of a circle. of a sphere, or of plane figures composed of curved lines.

Seki's technique for calculating the length of an arc of a circle depended upon giving a fixed number to the diameter of the circle, and was not much more sophisticated a method than that of Archimedes. His pupil Takebe used letters instead of numbers to represent a diameter and found infinite series, expressed exponentially, Matsunaga improved Takebe's method and increased the number of types of inifinite series capable of representing the different elements of circles.

The *yenri* process began with the inscription in the circle of a regular polygon to divide the circle or arc into equal parts; this method was, however, by definition limited, and could not be expanded to include curves other than circles and their arcs. Ajima expanded the process by dividing the diameter or chord into equal, small segments, initiating a technique somewhat similar to the definite integration of European mathematics. The earlier Japanese mathematicians had been concerned with subdividing the circle or arc directly; it was Ajima's contribution to proceed from the subdivision of the chord. He introduced his method in his *Kohai jutsu kai*, and used it for the basis of further calculations.

Japanese mathematicians were accustomed to using exponential notation for convenience in dealing with large numbers. Integration was also easier if an exponent were used, and double integrals were thus easily obtained. In the same year that Ajima developed his *yenri* method, he discovered a way to obtain the volume common to two intersecting cylinders by using double integration, which he presented in *Enchu kokuen jutsu*. Ajima's new method was a logical outgrowth of the method he described in *Kohai jutsu kai*, and required the application of the earlier technique.

For his work with logarithms, Ajima drew upon *Suri seiran*, a book published in China in 1723 that almost certainly incorporated some of the Western principles brought to China by the Jesuits. Sari seiran introduced the seven-place logarithmic

table into Japan, and also showed how to draw up such a table. It is apparent that Ajima knew this book, since he used the same terminology in setting up his own table of logarithms (actually antilogarithms). Ajima's table and its uses are described in *Fukru sampo*, and there is also a copybook of the table only, The Chinese logarithmic table was useful for multiplication and division. Ajima's was not. Ajima used his table to find the tenth root, and it was also useful in finding the power of a number. Before this table could be used, however, it was necessary to find the logarithm by division, The setting up of Ajima's table, as explained in Fukyu sampo, is based upon log 10=1, $\log^{10}$ therefore the logarithm of , while the value of 0.1 is 258925411. Ajima's tables permitted the calculation of a logarithm to twelve places.

Ajima drew upon Japanese mathematicl tradition for *yo jutsu*, problems involving transcribing a number of circles in triangles and squares. Ajima worte a major work on this subject, which included the problem described by Malfatti in 1803; in a given triangle, inscribe three circles, each tangent to the other and to two sides of the triangle. Although this problem became known as "Malfatti's question," it is obvious that Ajima's work preceded Malfatti's although it is not known when Ajima published his problem. Malfatti approached the problem analytically, while Ajima was concerned with finding the diameters of the circles, but it is apparent that the problems are essentially identical.

BIBLIOGRAPHY

Ajima's works include *Fukyu sampo; Kohai jutsu kai; and Enchu koken justsu*.

Shin'ichi Oya