Hua Lo-Keng Shapes Chinese Math

A prodigy, Hua is known for his research and for his efforts at popularizing math

Mathematics, like music, is famous for its prodigies—people who demonstrate enormous inborn talent, even without formal training. Although he modestly avoids using the word, prodigy aptly describes the eminent Chinese mathematician Hua Lo-Keng. A man who never received a degree—until last year, when he was given an honorary doctorate by the University of Nancy, in France—Hua has nonetheless become a major figure in the mathematical world. He has published 150 papers in respected journals and is the author of nine books. "He's an absolutely first-rate mathematician. He's an exceedingly gifted man," says Columbia University mathematician Lipman Bers.

Hua also is notable for his efforts in popularizing mathematics. Just prior to and during the Cultural Revolution of 1966 to 1970, he traveled throughout China teaching workers how to use mathematics to solve practical problems. During that time he spoke to huge numbers of people and drew enormous crowds for his mathematics lectures.

A soft-spoken, dignified man who looks younger than his 70 years, Hua sat in his Washington hotel room and talked to *Science* about his life as a mathematician. He is visiting the United States for 8 weeks and has accepted invitations to talk at 22 universities. He is accompanied by his daughter-in-law, Ke Xiao Ying, a cardiologist and his official physician, and by his assistant, Na Ji Sheng, a professional mathematician and one of Hua's former students.

Hua is perhaps best known for his work in number theory, in particular for his contributions to Waring's problem. The classical Waring's problem is to find a way to express any integer as a sum of powers of a number. This problem was solved by the German mathematician David Hilbert, but it was superseded by a more difficult problem that Hua worked on. The new problem is to express any integer as a sum of powers of prime numbers. According to Paul T. Bateman of the University of Illinois, this problem "still is not completely cleaned up." But in the 1940's Hua did find that every sufficiently large number n can be expressed as a sum of $6n^2 \log n$ powers of primes. His result, says Heini Halberstam of the University of Illinois, "is, on the whole, the best we have."

Halberstam, who is editing a collection of Hua's papers which will be published by Springer-Verlag, points out that one reason Hua is so impressive is that his research spans an unusually broad range of subjects, including the theory of functions of several complex variables, partial differential equations, and numerical analysis. Although he has recently put most of his efforts into popularizing mathematics, Hua continues to do some interesting theoretical work. For example, Hua and Wang Yuan of the Chinese Academy of Sciences in Peking devised a deterministic, number theoretic way to evaluate multiple integrals. This method, says Halberstam, "looks promising. In principle, it looks very nice."

Hua divides his life into "the three difficulties"—periods when he found it particularly hard to practice mathematics. The first difficult period, he says, was his youth. Born into a very poor family in a small village near Shanghai, Hua nonetheless managed to obtain 9 years of formal education. At age 15, he went to work in his father's tiny shop. "You Americans could not understand how small it was. We sold cigarettes one by one," he explains. At 18, he got a job as a clerk at the junior middle school he had attended. The salary of 18 yuan a month, which Hua says is less than $10, was very low, but much better than his salary in his father's shop. He was also married during this time. At age 19, he contracted typhoid fever, followed by arthritis, which left him lame.

While working in his father's store and at the school, Hua began teaching himself mathematics. Only three math books were available in his town—one on algebra, one on geometry, and a 50-page book on calculus. He read these and worked beyond them. Soon he was publishing papers in Chinese journals.

Hsiung Ch'ing-lai, who was chairman of the mathematics department at Tsinghua University in Peking, noticed Hua's papers and began making inquiries. He assumed Hua was educated abroad but the Association of Students Returned from Abroad had never heard of him. Finally, a professor who came from Hua's village told Hsiung that Hua was only a clerk at a junior middle school.

Hsiung was so impressed with Hua that he visited him at his home and invited him to come to the university. He could not offer Hua an assistantship because he had not graduated from school, but Hua was given a job as a secretary to help meet his expenses. Within $1\frac{1}{2}$ years, however, the university made an exception to its rule and gave Hua an assistantship. This marked the end of his first difficult period.

While at the university, Hua continued

Hua Lo-Keng and his daughter-in-law, Ke Xiao Ying

0036-8075/80/1024-0413$00.50/0

his research and began to send papers to Western journals. Many of these papers were returned because he kept discovering famous results such as Cauchy's theorem and Riemann's theorem. "I felt disappointed since I always repeated the work of others, but I felt that if great mathematicians could find these results, I could find them too and could go on from there," Hua says.

After a few years at the university, Hua received a China Cultural Foundation Fellowship to study at Cambridge. So, at age 25, he left his wife and three children at home and journeyed to England for his first taste of life at a great mathematical center. Hua was already known in the West for the papers he had published, and he found when he arrived at Cambridge that the eminent mathematician G. S. Hardy had left a note saying that he could have a degree in 2 years. To this Hua replied, "I'm coming to learn, not for a degree." He never enrolled for a degree but he stayed at Cambridge for 2 years, during which he published more than ten papers in number theory—an area in which the Cambridge mathematicians were particularly renowned.

In 1937, the year Japan invaded China, Hua returned from Cambridge to be a professor at the Southwest Associated University in Yunan province—a university formed from what remained of Tsinghua, Peking, and Yenching universities. The professors at these three universities had left their libraries and facilities and fled into the interior of China, where they regrouped to form the new university.

The Sino-Japanese War marks the second difficult period of Hua's life. "Academic work almost stopped and life was very hard," he says. He was isolated from the rest of the academic world and had no access to mathematics journals. Inflation was terrible and, like most Chinese, he found it difficult to feed his family. Still, during that time he wrote more than 20 papers and completed his first book, *The Additive Theory of Prime Numbers*, which is still in use.

In 1946 the war with Japan was over, and Hua accepted an invitation to visit the Institute for Advanced Study in Princeton. After 2 years at Princeton, Hua joined the University of Illinois, where he made a lasting impression on several young mathematicians. Hua "is a man filled with ideas and suggestions. He was very pleasant to work with," says one of his former students, Raymond Ayoub of Pennsylvania State University.

In 1950 the Chinese Communists gained power and Hua returned to China, where he was made director of the Institute of Mathematics in Peking. "That was a good period. My students are now quite prominent. I wrote many books and many papers there," Hua says.

At the end of the 1950's, Hua became interested in popularizing mathematics. He reasoned that "the most essential thing for China is to raise its standard of living." As a pure mathematician, he felt any help he could give would be indirect, yet he had the theoretical background to do applied mathematics and to teach the Chinese how to use mathematics to solve practical problems. For 15 years, starting in 1960 and including the years of the Cultural Revolution, he devoted himself to teaching mathematics to the masses, visiting 23 of the 30 provinces of China and journeying to countless factories.

For all his trials, Hua has managed to exert an enormous influence on Chinese mathematics . . .

Hua thought very carefully about how to popularize mathematics. "Experts do not always have a common language with the workers. This is most difficult to overcome." His strategy was first to solve a practical problem. For example, experienced workers who want to balance a grinding wheel can take 2 hours to do so. Inexperienced workers can take days. "If they are worried about balancing wheels and you try to teach them about calculus or infinite dimensional spaces, they are not interested. But if I can tell them a way to balance the wheel in a few minutes, they will become my very good friends," Hua says. Then the door is open to teaching workers the theory and the methods behind this solution to their problem.

When he first came to a factory, Hua recalls, the workers would be respectful but distant. "They would always salute me and would call me Professor Hua or President Hua (because he was president of the Mathematics Institute). After I stay there, they find me useful. Then they change my name to Old Hua," an intimate term but one that also connotes respect.

As an example of how he built up a following, Hua tells a story about making antifreeze. A group of workers had spent 6 months trying 137 different chemical combinations to make an antifreeze. Finally, they decided they had found the best chemical proportions and were able to get the freezing point of their oil to −37°C. Hua visited the plant and asked for the records of their experiments. He recognized immediately that the antifreeze problem was a problem of linear programming. Within 30 minutes, he suggested a new combination of chemicals.

Afterward the workers told Hua that they did not want to try his combination because they thought they had exhausted all possibilities. But they decided to try it anyway, reasoning that if it was not effective Hua might be convinced that he could not improve their work. When they tried Hua's combination, it lowered the freezing point of the oil to −42°C. "We got quite a good fame there. The whole factory, then the whole city came to us," Hua recalls.

Hua's mathematics research, however, suffered during the Cultural Revolution, and his motives in popularizing mathematics were attacked. It was said that he traveled to the provinces only to see the mountains and the water. After the Revolution, Hua says, his friends defended him by saying, "How ignorant they [the critics] are. Do they not know that Hua is lame and so cannot climb mountains. And why did he go south in the summer and north in the winter?" As did most Chinese, Hua found life during the Cultural Revolution to be exceedingly hard. He describes that time as his third difficult period.

Yet despite the difficulties, Hua still secretly worked on mathematics research. He traveled with 10 to 20 assistants, all of whom were his former students. He would discuss ideas with them in the middle of the night.

For all his trials, Hua has managed to exert an enormous influence on Chinese mathematics as well as to become renowned in the Western world. "He probably has influenced directly more people than any mathematician in history has. He has a way of selling math," says Ronald Graham of Bell Laboratories, one of Hua's hosts on this U.S. trip. Atle Selberg of the Institute for Advanced Study in Princeton says reflectively that if Hua had remained in the United States at the end of World War II, as did many of his countrymen, "undoubtedly he would have contributed more to mathematics. On the other hand, I think it is very important for Chinese mathematics that he went back. It is hard to see what they would have had had he not returned."—GINA BARI KOLATA