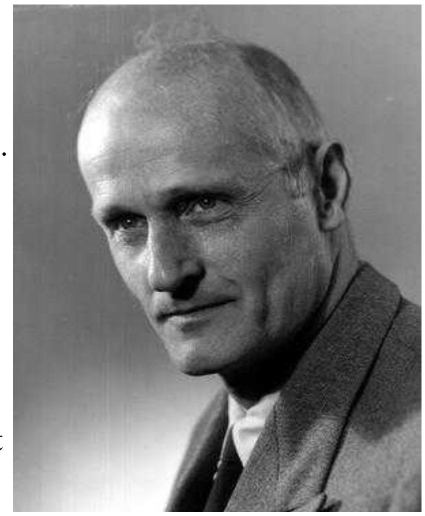
STEPHEN COLE KLEENE

American mathematician and logician **Stephen Cole Kleene** (January 5, 1909 – January 25, 1994) helped lay the foundations for modern computer science. In the 1930s, he and Alonzo Church, developed the *lambda calculus*, considered to be the mathematical basis for programming language. It was an effort to express all computable functions in a language with a simple syntax and few grammatical restrictions.



Kleene was born in Hartford, Connecticut, but his real home was at his paternal grandfather's farm in Maine. After graduating summa cum laude from Amherst (1930), Kleene went to Princeton University where he received his PhD in 1934. His thesis, *A Theory of Positive Integers in Formal Logic*, was supervised by Church. Kleene joined the faculty of the University of Wisconsin in 1935. During the next several years he spent time at the Institute for Advanced Study, taught at Amherst College and served in the U.S. Navy, attaining the rank of Lieutenant Commander. In 1946, he returned to Wisconsin, where he stayed until his retirement in 1979. In 1964 he was named the Cyrus C. MacDuffee professor of mathematics. Kleene was one of the pioneers of 20th century mathematics. His research was devoted to the theory of algorithms and recursive functions (that is, functions defined in a finite sequence of combinatorial steps). Together with Church, Kurt Gödel, Alan Turing, and others, Kleene developed the branch of mathematical logic known as recursion theory, which helped provide the foundations of theoretical computer science. The Kleene Star, Kleene recursion theorem and the Ascending Kleene Chain are named for him.

An algorithm, derived through Latin translation from the name of al-Khowarizmi, the Arabic author of a treatise on calculation with Hindu-Arabic numerals, is a scheme for performing computations with numbers using the operations of arithmetic. An oversimplification is that recursive theory deals with problems that can be solved by humans or computers in a finite number of steps. Recursive theory is important because it can be used to show that some mathematical problems cannot be solved, no matter how much computer power is available. Recursion theory led to the theory of computable functions, those that can be calculated by a digital computer.

Kleene's influential and authoritative 1952 book, *Introduction to Metamathematics*, is a classic in the field of logic. It has been translated into Russian, Chinese, Romanian, and Spanish. Briefly stated, Metamathematics is the study of the logic of mathematics. A major feature of Kleene's book is a clear formulation of Gödel's incompleteness theorem. This theorem asserts that in any specific and adequate formal logic system containing all of number theory there are true statements that cannot be proven. Kleene also contributed to mathematical intuitionism as formulated by L.E.J. Brouwer as a co-author of *The Foundations of Intuitionistic Mathematics* (1965). Kleene's other works include his book *Mathematical Logic* (1962). In the first chapter of *Mathematical Logic*, Kleene gives students a fair warning:

> "It will be very important as we proceed to keep in mind this distinction between the logic we are studying (the object logic) and our use of logic in studying it (the observer's logic). To any student who is not ready to do so, we suggest that he close the book now, and pick some other subject instead, such as acrostics or beekeeping."

Kleene built a widely acclaimed logic group in the Mathematics Department at Wisconsin. He served as Chair of the department on two occasions, from 1957 to 1958, and from 1960 to 1962, and was the chair of the Department of Numerical Analysis (now Computer Sciences) from 1962 to 1963. Kleene was the driving force behind the building of Van Vleck Hall in 1963, and from 1969 to 1974 he was the Dean of the College of Letters and Science. In 1999, the University of Wisconsin honored him with the naming of the Stephen Cole Kleene Mathematics Library. He pronounced his last name "klay'nee," not "klee'nee" or "kleen" and his first name as "steev'n" not "stef'n." His son, Ken reports, "As far as I am aware this pronunciation is incorrect in all known languages. I believe that this novel pronunciation was invented by my father."

In the 1960s I was privileged to attend a course in metamathematics taught by Stephen Kleene, although at the time, I wasn't certain it was a pleasure. In an eight-week summer session, he took us for a brisk romp through his *Introduction to Metamathematics.* The material is on three levels, mathematics, logic, and metamathematics. We had to keep track of a great number of symbols. To distinguish them Kleene used three different pieces of colored chalk, one for each of the levels. Even so, on one occasion he said, "We will denote … by a star." Someone pointed out that he had already used a star to represent something else. Without a moment's hesitation, he said, "OK, we'll represent … by a huge star." On several occasions Kleene would explain some theorem or share an insight, and muse to himself, "Who first thought of this?" Then brightly say, "Oh, yes, I did."

Kleene made no assignments other than to read his book and the students were concerned about how the grades would be determined. The only exam was given on the final day of the course. As we struggled with our answers to his questions, we noticed that he was sitting at the desk at the front of the room making out the grade sheet for the course. This put our minds to rest. Whatever we wrote would probably not be read as he had already recorded our grades. Through the years this course has greatly influenced my understanding and appreciation for the foundations of mathematics. While I have difficulty recalling the fine points of the course, I have been profoundly affected by the bigger picture in ways I still find difficult to explain. For the first time, I saw mathematics as so much more than a mere collection of techniques to be mastered and applied.

Quotation of the Day: "Metamathematics must study the formal system as a system of symbols, which are considered wholly objective. This means simply that those symbols are themselves the ultimate objects, and are not being used to refer to something other than themselves. The metamathematician looks at them, not through and beyond them; thus they are objects without interpretation or meaning." – Stephen Cole Kleene.