

# The Four-Color Problem

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## *Kenneth Appel and Wolfgang Haken*

Kenneth Appel was born in Brooklyn and received his doctorate from the University of Michigan in 1959. He has been associated with the University of Illinois since 1961.

Wolfgang Haken was born in Germany in 1928. He received his doctorate in 1953 from the University of Kiel in Germany. Since a two-year stay at the Institute for Advanced Study at Princeton from 1963 to 1965 he has been associated with the University of Illinois.

*In 1978 the postage meters of the University of Illinois bore for a time the inscription "Four Colors Suffice"—a rather modest and somewhat belated tribute to the monumental effort that had been conducted at the University of Illinois to resolve the four-color problem. The problem, its history, and the effort required for its solution are all carefully outlined in this essay.*

*Appel and Haken are the mathematicians who devised and orchestrated the herculean task of listing and reducing the large number of configurations needed to produce the proof. This effort has not, surprisingly enough, been greeted with universal acclaim in the mathematics community. The complaints are based on the fact that all details of "real" proofs in mathematics can be read and confirmed in a reasonable amount of time by other mathematicians. These authors' proof obviously does not meet this requirement. The number and variety of cases that must be checked for this proof could not be done by hand in a single lifetime, much less a few evenings sandwiched in between grading examinations and writing snide comments on dissertations.*

*As Appel and Haken quite modestly suggest toward the end of this essay, the type of proof they have devised may be the first of a completely new type of mathematical result. Such new theorems will have their gross outline and direction guided by human hands, but their endless details will be checked and rechecked only by computer. However distressing such a prospect may be to those purists who demand that all mathematics worthy of the name must be so succinct as to allow engraving on tablets of stone, to many the author's vista is a most exciting one. Truth, it would seem, is truth. If we must restrict our body of mathematics to that portable by an atherosclerotic professor emeritus in oversized type, we may well miss much of value and use along the way.*

IN 1976, THE Four-Color Problem was solved: every map drawn on a sheet of paper can be colored with only four colors in such a way that countries sharing a common border receive different colors. This result was of interest to the mathematical community since many mathematicians had tried in vain for over a hundred years to

prove this simple-sounding statement. Yet among mathematicians who were not aware of the developments leading to the proof, the outcome had rather dismaying aspects, for the proof made unprecedented use of computer computation; the correctness of the proof cannot be checked without the aid of a computer. Moreover, adding to

*Source: Kenneth Appel and Wolfgang Haken, "The Four-Color Problem," in *Mathematics Today: Twelve Informal Essays* (Springer-Verlag, 1978), pp. 153–180. Copyright by Springer. (References omitted.)*

