

At this stage, Radziszowski entered the picture. Communicating almost entirely by electronic mail, he began collaborating with McKay in a concerted effort to establish the Ramsey number for four acquaintances and five strangers.

Individually checking the 10^{65} possible graphs was clearly out of the question. McKay and Radziszowski concentrated on developing efficient procedures, or algorithms, for such operations as mathematically "gluing" together small graphs to make larger graphs. They also spent considerable time testing their method.

Because their search technique involved using the same computer program many times with different data, the researchers could readily partition their task into small pieces. This meant they could do the necessary computations on lots of desktop computers rather than having to rely on a single supercomputer.

"Both of our institutions have considerable numbers of personal computers — mostly Sun workstations — that sit in staff offices or in student laboratories," Radziszowski says. "In the middle of the night and on weekends, many of these computers are available for other uses. At some times, we had about 110 computers working simultaneously."

To rule out potential errors, the researchers did everything twice. Each one wrote an independent computer program that implemented the same basic ideas in

Number of Friends	Number of Strangers	Ramsey Number
3	3	6
3	4	9
3	5	14
3	6	18
3	7	23
3	8	28
3	9	36
4	4	18
4	5	25
5	5	?

This table lists all known Ramsey numbers. Mathematicians have established that the Ramsey number for five friends and five strangers is at least 43 but no larger than 49.

a slightly different way. The companion computations required a total of 11 years of computer time.

"The total amount of computer time might be the greatest ever used to solve a problem in pure mathematics," Radziszowski says.

The work of Radziszowski and McKay may aid others conducting monstrous mathematical searches. "We developed a method of collapsing such searches by, in effect, doing many cases at the same time," he says. "Our technique will not apply in every situation, but we are confident there are important practical problems around for which it will be a major advance."

"What happens in mathematics a lot is that a particular problem serves as a kind of milepost," Graham says. "You attack this particular problem, you develop tools [to solve it], and the tools turn out to be what are important."

At the same time, the prospects of determining the Ramsey number for the next important case — that of five acquaintances and five strangers — appear bleak. "We do not believe that present techniques are adequate for the determination of any further Ramsey numbers," Radziszowski says. "Even a thousandfold increase in computer power — which will probably happen within two decades — may not be enough."

Graham agrees. "It's going to be a while before you see the next number," he says. "This is like a little plateau. You develop some tools and you're climbing. Eventually, you get there. Then the question is what you need to do to push further. That's the job of the next generation [of mathematicians]." □

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The Folklore of Birds — Laura C. Martin. In addition to general descriptions, habitat information, and illustrations, Martin provides fascinating details about the heritage, lore, common uses, and habits of almost 100 birds from the Black-footed Albatross to the Common Yellowthroat in this delightfully insightful reference. For example, the entry on Yellow-billed cuckoos tells why cuckoos are considered lazy and why they also thought to be capable of forecasting the weather and the future. Globe Pequot, 1993, 231 p., b&w illus., hardcover, \$24.95.

The Forgotten Plague: How the Battle Against Tuberculosis Was Won and Lost — Frank Ryan. Estimates indicate that more than 1 billion people worldwide have died of TB over the last two centuries. And, though the discovery of new drugs shortly after World War II seemed to put this plague behind us, TB is now making a frightful return, reports Ryan. Here he chronicles the disease through the early part of the century — with emphasis on the work of scientists who thought they had cured TB almost 50 years ago — and brings us to today's alarming resurgence. Little, 1993, 460 p., b&w plates, hardcover, \$24.95.

Geology Underfoot in Southern California — Robert P. Sharp and Allen F. Glazner. A compilation of provocative vignettes portraying some of the more interesting sites in the geologically diverse area of southern California. Each section describes what the geology of the area looks like, explains how the earth came to be formed in that way, and assesses the area's geologic stability. Locations covered include Red Rock Canyon, Blackhawk Slide, San Onofre Nuclear Power Plant, and the Cristianitos Fault, among others. Includes a glossary and a map of each location. Mountain Pr, 1993, 224 p., b&w photos and illus., paperback, \$12.00.

The HarperCollins Illustrated Medical Dictionary — Ida G. Dox, B. John Melloni, Gilbert M. Eisner. Formerly known as *Melloni's Illustrated Medical Dictionary*, this third edition provides concise definitions of medical terms ranging from azoospermia to zona pellucida, as well as drawings to clarify many of the definitions. HarperCollins, 1993, 533 p., b&w illus., paperback, \$19.00.

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Through a Universe Darkly: A Cosmic Tale of Ancient Ethers, Dark Matter, and the Fate of the Universe — Marcia Bartusiak. Recounts the work of famous and not-so-famous scientists who have dedicated their lives to probing a mystery first raised by the Greek philosopher Thales: Of what is the universe composed? A comprehensive and entertaining look at the history of our knowledge of the universe and what we may soon find out. HarperCollins, 1993, 383 p., b&w photos and illus., hardcover, \$27.50.

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