foods—comments that his organization would not oppose low-allergen foods if they prove to be safe. But he wonders about "identity preservation," a term used in the food industry to describe the deliberate separation of genetically engineered and nonengineered products. A batch of nonengineered peanuts or soybeans might contaminate machinery reserved for low-allergen versions, he suggests, reducing the benefit of the gene-altered food. Such issues of identity preservation could make low-allergen genetically modified foods too costly to produce, Chabot Dreyer admits. But, she says, "it's still too early to see if that's true."

Biotech's contributions to fighting food allergies need not require gene modification of the foods themselves, Giddings notes. He suggests that another approach might be to design monoclonal antibodies that bind to and eliminate the complexes formed between allergens and the subclass of the body's own antibodies that trigger allergic reactions. "Those sorts of therapeutics could offer a huge potential," Giddings states, and may be more acceptable to a public wary of genetically modified foods. He definitely sees an untapped specialty market. "When you find out your child has a life-threatening food allergy, your life changes in an instant," Giddings remarks. "You never relax." Not having to worry about every bite will enable Giddings—and his son—to breathe a lot easier.

MATHEMATICS

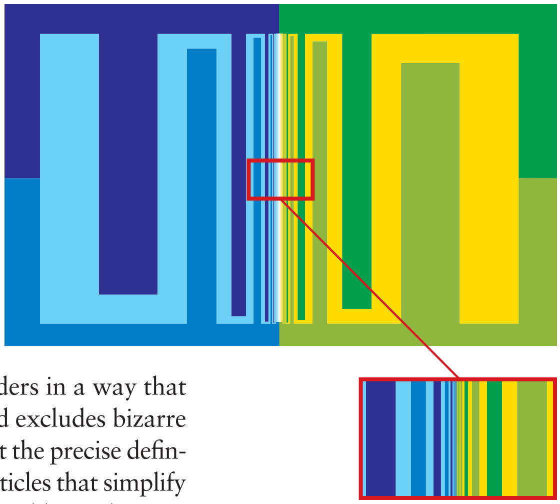
# Color Madness

ODDBALL MAPS CAN REQUIRE MORE THAN FOUR COLORS BY GEORGE MUSSER

**Science operates** according to a law of conservation of difficulty. The simplest questions have the hardest answers; to get an easier answer, you need to ask a more complicated question. The four-color theorem in math is a particularly egregious case. Are four colors enough to identify the countries on a planar map, so that two bordering countries (not counting those that meet at a point) never have the same color? The answer is yes, but the proof took a century to develop and filled a 50-page article plus hundreds of pages of supplementary material.

More complicated versions of the theorem are easier to prove. For instance, it takes a single page to show that a map on a torus requires at most seven colors. The latest example of unconventional cartography comes from philosopher Hud Hudson of Western Washington University in a forthcoming *American Mathematical Monthly* paper. He presents a hypothetical rectangular island with six countries. Four occupy the corners, and two are buffer states that zigzag across the island. The twist is that the zigs and zags change in size and spacing as they go from the outskirts toward the middle of the island: each zigzag is half the width of the previous one. As the zigzags narrow to nothingness, an infinite number of them get squeezed in.

Consequently, the border that runs down the middle of the island is a surveyor's nightmare. If you draw a circle around any point of the border, all six countries will have slivers of territory within that circle. No matter how small you draw the circle, it will still intersect six countries. In this sense, the border is the meeting place of all six countries. So you need six colors to fill in the map. By extending the procedure, you can prepare maps that require any number of colors.



SIX COLORS are needed to fill in this map, with its infinitely meandering countries.

HUD HUDSON *Western Washington University*

The standard four-color theorem defines borders in a way that hews to common sense and excludes bizarre cases such as Hudson's. But the precise definition is usually left out of articles that simplify the theorem for the general public. "The popular formulation of the four-color problem, 'Every map of countries can be four-colored,' is not true, unless properly stated," says Robin Thomas of the Georgia Institute of Technology. Thomas is one of the co-authors of a shorter proof of the theorem—just 42 pages.