Cosmides and her husband, biological anthropologist John Tooby, also at Santa Barbara, propose that human wars began over women in the Pleistocene, hundreds of thousands of years ago. And once a few early hunter-gatherer groups started battling over women, the researchers say, the victors would produce more offspring. That would lead to the selection of certain complex cognitive mechanisms in later generations, such as the ever-improving ability to form groups and go forth in battle.

The reason Tooby and Cosmides think that the first warriors battled over women instead of food is that it isn't worth the risk to die for fruit or land. If food was scarce and a group of men went after another group's food stocks, they were taking a big chance: Their own offspring, already malnourished, could starve if the men were killed in the fighting and didn't return to help scratch out a living.

But women, the researchers argue, are worth dying for. A group of men would benefit from initiating a battle to claim new women if they were flush with food and other resources. Then they would know their existing mates and offspring could survive without them. In evolutionary terms, they don't lose much by going to war for women—even if many were to die, their offspring would survive to pass on their genes. And if the group won and gained new mates, the male coalition would bear more young on average, even if a few men lost their lives in the effort.

Similar theories about the influence of sexual competition on the evolution of male behavior have been put forth by anthropologists Richard Alexander of the University of Michigan and Richard Wrangham of Harvard University. Moving from theory to ethnographic observation, University of California anthropologist Napoleon Chagnon has suggested that the Yanomamo he studies are fighting to capture new women. Chagnon's proposal has been vigorously criticized by University of Florida anthropologist Marvin Harris and Rutgers University anthropologist Brian Ferguson, who argue that scarce food and land are more immediate—and more powerful—incentives for warfare than are women. With the new work from Tooby and Cosmides, however, Chagnon feels that more of his colleagues are beginning to see his point of view. "Why fight over bananas," he asks, "when you can fight over women?"

–Ann Gibbons

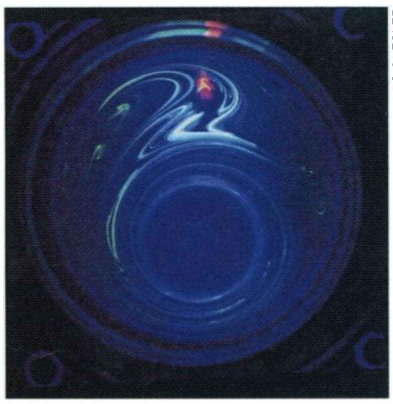
CHAOS THEORY

How Islands Survive in a Chaotic Sea

When you stir cream and sugar into a cup of coffee, little pockets sometimes remain stubbornly unmixed, no matter how vigorously you stir. Much the same thing happens in the giant mixing vats of the chemical industry and even on Jupiter, where the Great Red Spot marks a colorful storm that somehow stays intact amid the planet's whirling atmosphere. In recent years, so-called chaos theory has sharpened researchers' understanding of mixing, but the puzzle of these coherent islands in a sea of disorder has only deepened. Now Troy Shinbrot and Julio Ottino of Northwestern University have proposed a way to make sense of them.

The islands posed a mystery because, according to chaos theory, any two points that start off close together in a chaotic fluid should end up unpredictably far apart as the mixing proceeds. But in last week's *Physical Review Letters* Shinbrot and Ottino offer theoretical studies to show how the very processes that mix a fluid can sometimes preserve small eyes in the storm. They've also backed up their analysis with practical demonstrations, which they have yet to publish. "This is a nice stepping stone towards a better understanding of coherence," says Steve Wiggins, an authority on nonlinear dynamics at the California Institute of Technology.

Shinbrot and Ottino's theoretical analysis starts with the description of any mixing process that was devised at the turn of the century. As any mixture is stirred, each parcel of fluid "can either stretch like a rubber band or it can fold over," says Shinbrot, yielding a horseshoe shape. With each successive stretch and fold, the distance between any two particles along the legs of the horseshoe will randomly increase by anywhere from two to 100 times, ensuring relatively complete mixing. Such unpredictable divergence is the hallmark of chaos, theorists realized in the 1960s, implying that any fluid mixing process is inherently chaotic.



LEO BRESLER

Little red spot. Like the famous red spot of Jupiter, a patch of red dye remains intact in a swirl of chaotic mixing.

You might expect chaotic mixing to require random stirring forces, such as those generated by turbulence. If so, Shinbrot and Ottino would have had a harder time analyzing it, because the math needed to describe turbulent mixing is only just being developed, according to Wiggins. As Ottino was one of the first to show, however, a chaotic system can be achieved without turbulence. A smoothly mixed fluid still undergoes the stretching and folding that produces horseshoes. So Shinbrot and Ottino tackled coherence by examining one of these simpler systems.

In their paper, the pair shows that the horseshoes, the very hallmarks of chaos, actually help preserve coherent structures. They examined what happens right at the vertex of a horseshoe, where the stretched fluid parcel folds in half. One way to think about the process is to imagine a piece of taffy with a blue stripe down its middle. If you stretch the taffy perpendicular to the stripe, then fold it in half, down the center of the stripe, the stripe will be displaced—moved to the top of the candy—but it will stay together. If, during repeated cycles of stretching and folding, which correspond mathematically to the mixing cycles, the fold always stays in the blue patch, the blue dye will never mix with the rest of the taffy.

Much the same thing can happen in a fluid stirred with a periodic motion, even a motion that appears impossibly complex, Shinbrot and Ottino's analysis showed. Folds can recur over and over in the same area, preserving coherent structures. And that's exactly what they saw when they followed their theoretical recipe in the lab. They filled the space between two cylinders, one inside the other, with blue glycerine, then added a spot of red and mixed the system by twisting the cylinders back and forth in opposite directions. The rotations stretched and folded the entire fluid, but when they were controlled to keep a fold within the red glycerine on every mixing cycle, the two dyes stayed separate after numerous mixings.

Knowing how islands can be preserved within a chaotic flow could suggest the converse—ways to eliminate them by avoiding periodic stirring. And that could be valuable to the chemical industry, helping it to guard against incomplete mixing, which can degrade products. "Ideally, you would like to have recipes where you can get rid of these unmixed regions," says Ottino.

But the theory leaves some larger challenges unanswered, says Wiggins—it can't fully explain such grand examples of coherent structure as Jupiter's red spot. Jupiter's atmosphere is truly turbulent, while Shinbrot and Ottino looked only at coherence in a periodically mixed system. Still, says Ottino, "it's always exciting to find order within the mess."

–Karen Fox