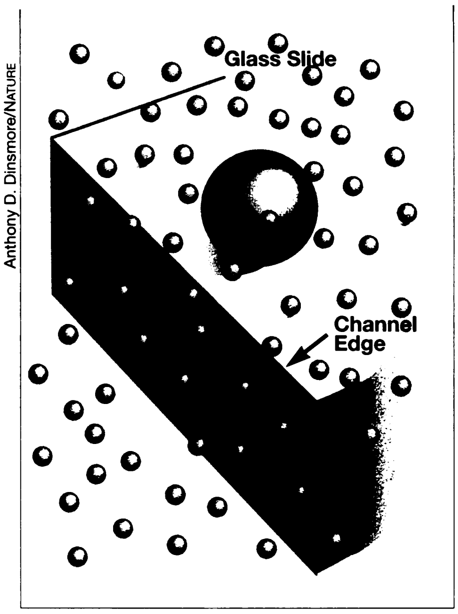
Entropy keeps small particles on the edge



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To maximize entropy, the small spheres trap the larger particles on the channel edge, away from open space.

The second law of thermodynamics—which says that entropy, or disorder, always increases—is the bane of physics. Whether limiting an engine's efficiency or scrambling the socks in a drawer, entropy thwarts many a plan. Physicists have now turned the tables on entropy, however, using it to marshal microscopic spheres into an organized pattern.

Experimenters have long known that if they mix two different sizes of spheres in salt water, the larger particles cluster against the container wall (SN: 4/2/94, p. 223). Building on this research, a new method harnesses entropy to line up particles in neat rows.

"The cool idea is making shapes on the surfaces to trap particles," said Arjun G. Yodh of the University of Pennsylvania in Philadelphia. Yodh and his colleagues at Penn and at the University of California, Santa Barbara describe the experiment in the Sept. 19 Nature.

The group packed a mixture of polystyrene spheres into a drop of salt water between two glass microscope slides and adjusted the salinity of the water so that the spheres neither floated nor sank. Yodh and his colleagues used numerous 0.08-micrometer balls and a few 0.46-micrometer ones. The researchers also etched a channel into the lower glass slide.

In the middle of the mixture, the small spheres battered their larger brethren randomly on all sides. When experimenters placed the big particles directly on the lower glass surface, however, the bumping by small spheres sent them staggering until they reached the edge of the channel. Though they teetered there, the large spheres never fell in, because the motion of the small spheres in and near the channel barred their entry.

The obstructive behavior of the small spheres comes from their tendency to maximize entropy, explains Yodh. The tiny spheres spread themselves out in as disorderly a fashion as possible. The large spheres would behave in the same way, but outnumbered by small particles bent on maximizing their own freedom, the big ones remain pinned to the glass surface like wallflowers at a raucous high school dance.

Whenever a big globe threatens to move into the open space over the etched channel, which would further limit the small spheres' movement, the small spheres push back with a cumulative force that maximizes disorder.

The force exerted by all the small spheres on each of the larger ones is only 40 femtonewtons (10^{-15}N)—a little less than the gravitational pull between two people standing a kilometer apart. "This is the first direct measurement of entropic interaction," says physicist David G. Grier of the University of Chicago.

Yoking entropic forces to push molecules into place might pay off in better lasers, paints, and models of cell behavior, according to Grier. "Rather than calculating and then ignoring entropy, we're actually using it." — *D. Vergano*

The baddest of the bad cholesterols?

For some one-quarter to one-third of people in the United States with heart disease, most of the low-density lipoprotein (LDL)—the so-called bad lipoprotein—circulating in the blood takes the form of relatively small, unusually dense particles. Although test-tube studies had suggested that these small LDLs, with their loads of fats and cholesterol, could promote artery-clogging plaque more effectively than large LDLs, there remained a nagging doubt about whether the small version preceded heart disease or developed as a consequence of it.

Two studies in the Sept. 18 Journal of the American Medical Association now show that the body begins producing these unusual LDLs years before a heart attack occurs. Moreover, both studies found, the smaller an individual's LDLs, the greater his or her risk of heart attack.

The Stanford Five-City Project followed more than 9,000 Californians between 1979 and 1990. In their analysis of data from the project, Christopher D. Gardner of the Stanford University School of Medicine and his colleagues identified 90 men and 34 women who suffered a first heart attack during the study. The researchers compared this group to an equal number of men and women of the same age, ethnicity, and geography who remained heart-healthy, focusing on potential risk factors measured early in the program.

Overall, the diameter of LDLs in the people who would go on to develop heart attacks tended to be about 0.5 nanometer, or 2 percent, smaller than that of their healthy counterparts. The researchers used statistical analyses to gauge the significance of LDL size in comparison to other risk factors, such as blood pressure, weight, total cholesterol in the blood, and serum triglycerides.

"When we did that, LDL size came out on top," Gardner told Science News. "It was the best predictor"—until they considered the ratio of all cholesterol in the blood to that of so-called good, or high-density lipoprotein (HDL), cholesterol. The total-to-good ratio then turned out to be most predictive.

On average, women had somewhat larger LDLs than men—about 0.5 nanometer bigger—"which is pretty interesting," Gardner says. The size of the LDLs might explain, in part, why women as a group develop less heart disease than men, he suggests.

Researchers at the Harvard School of Public Health in Boston and Lawrence Berkeley (Calif.) National Laboratory conducted a similar study, using as their starting population roughly 15,000 male physicians. The 266 men who suffered a first heart attack during the 7-year study had significantly smaller LDLs than the 308 healthy doctors to whom they were matched.

"But the big surprise came with the analysis of triglycerides," recalls Harvard's Meir J. Stampfer, who led this study. When concentrations of these fats in the blood were plugged into the calculations, the independent predictive value of the small LDLs disappeared. Similarly, any added value of HDLs in predicting disease also disappeared after accounting for triglycerides.

While all the laboratory experiments argue that LDL diameters should be among the most useful predictors of heart disease risk, "they're not—at least as they're currently measured," observes Josef Coresh of the Johns Hopkins Medical Institutions in Baltimore. Even if the small LDLs are a primary agent fostering atherosclerosis, he says, the standard and more easily measured values—especially triglyceride concentrations and the ratio of total cholesterol to HDL cholesterol—are at least as predictive of disease. — *J. Raloff*