Liquids that tiptoe on the edge of solidity

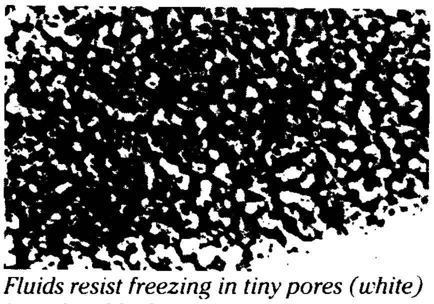
In extremely tight spots, liquids get away with some very unliquid-like behaviors, often masquerading as solids. Some refuse to freeze even when chilled far below their freezing point for weeks at a time. These surprising findings, described this week in separate reports at a meeting of the Materials Research Society in Boston, may help chemists to design better lubricants, electronic engineers to build faster chips, and petroleum hunters to detect hidden oil reserves.

In one set of studies, Jacob N. Israelachvili and his colleagues at the University of California, Santa Barbara, measured physical properties of ultrathin liquid films — sometimes no more than a single molecule deep — confined between a pair of supersmooth mica plates. With the plates far enough apart to sandwich at least 10 layers of liquid molecules, the molecules behave like a "normal," bulk liquid in a beaker. But pinching the plates together so that only a few molecular layers can squeeze between them elicits deviant behavior. "We get liquids that behave like solids," Israelachvili says.

These rigid liquid films display the orderly molecular arrangement of a solid. But when the researchers briefly apply a shear force by sliding the plates across each other, the molecules "melt" into the disordered structure of a liquid or a partially ordered, liquid crystalline state before "refreezing" into a solid-like state.

Israelachvili reports that the liquid films under shear force can have viscosities surpassing those of their bulk-liquid counterparts by a factor of 10 billion. That's such a dramatic difference that he now questions whether viscosity — a fundamental property of bulk liquids and liquid lubricants — can apply to ultrathin liquid films, which seem to hover on the edge of solidity.

In other studies, a team led by David D. Awschalom of IBM's Thomas J. Watson Research Center in Yorktown Heights, N.Y., confined fluids within tiny compartments — some no more than 20 atoms across — in specially prepared glass blocks. Even when chilled as much as 40 percent below their normal freezing temperatures, liquid oxygen and some other fluids can spend weeks in a remarkably stable liquid state, the researchers report. Awschalom suggests chip designers might exploit the effect to cool superdense circuitry with minuscule "integrated refrigerators," consisting of channels micromachined into the chip's silicon base and filled with a supercooled fluid.



Fluids resist freezing in tiny pores (white) in a glass block.

The group also found that sound travels through the confined, supercooled fluids at the same speed and dampens over the same distance as it would in a solid. Usually, sound travels more slowly and dampens more quickly in liquids. Awschalom speculates that arctic oil hunters who rely on sound data may mistake supercooled oil for rock.

— I. Amato

Genetic propensity to common cancers found

Researchers have identified an inherited gene defect that heavily predisposes individuals to breast cancer and some other malignancies. Cancer scientists say the finding provides a new window on the molecular underpinnings of hereditary cancers and should lead to tests that identify people likely to get the diseases.

"All this will presumably be extremely helpful in early diagnosis of people at risk," says David Malkin of the Massachusetts General Hospital Cancer Center in Boston, who participated in the research effort. "We'll be able to say, 'Yes, you carry this mutation . . . and you are at risk,' or 'No, you don't.'"

Early diagnosis and treatment provides the best insurance against death from cancer, Malkin and others note. In the case of breast cancer, women who recognize they are at high risk may initiate a range of options from frequent breast exams to hormonal therapy to — in extreme cases — preemptive mastectomy.

The discovery emerged in a study of a rare syndrome called Li-Fraumeni. Family members who inherit the condition have healthy childhoods. By age 30, however, nearly 50 percent develop one or more of several different cancers, including brain tumors, osteosarcoma, leukemia, and especially breast cancer. More than 90 percent develop cancer by age 70. In the Nov. 30 Science, Malkin and researchers at four U.S. medical centers describe five Li-Fraumeni families in which individuals with syndrome-linked cancers all carry inherited mutant versions of a gene called p53, while most unaffected members do not.

"It's a very important finding," says Alfred G. Knudson of the Fox Chase Cancer Center in Philadelphia, who has followed the work. Until now, he says, the only gene defects known to cause adult cancers were those that accumulated through a lifetime. "Now for the first time we have a gene in the germ line shown to be a high risk factor for a common adult cancer, namely breast cancer."

Scientists are familiar with the p53 gene, which in its normal form helps control cell division and prevent cancer. Indeed, researchers frequently find damaged p53 genes in tumor cells from noninherited cancers, but the gene's role in inherited cancers went unrecognized. The question, Knudson explains, has been whether p53 simply exacerbates the effects of other cancer-causing genes or whether it's a major player on its own. He says the new study "shows that it can be very, very critical indeed."

Malkin says he and others are now screening broader populations of cancer victims to see what percentage of various malignancies may be due to flawed p53 genes. "We're not suggesting that every familial cancer syndrome involves p53," he says. "But the data suggest it may be a very important player in breast cancer."

Still, says co-author Stephen H. Friend of Massachusetts General, "People shouldn't think that p53 is *the* gene for hereditary breast cancer, because there are likely to be several of them. We have no idea what various genes may be responsible for this very heterogeneous group of diseases we call hereditary breast cancer."

— R. Weiss

San Andreas fault may have many faces

A close examination of last October's Loma Prieta earthquake and the great San Francisco quake of 1906 has yielded a surprising conclusion: The two shocks appear to have ripped different faces of the San Andreas fault. If so, geoscientists may have underestimated the seismic hazard remaining in the Santa Cruz region after last year's deadly jolt.

"We have to be awfully cautious about saying we understand a certain area and we know what its seismic potential is," says Paul Segall of Stanford University and the U.S. Geological Survey (USGS) in Menlo Park, Calif.

Both the 1989 and 1906 earthquakes broke the San Andreas fault on a segment that runs through the Santa Cruz Mountains. To compare the two events, Segall and Mike Lisowski of the USGS examined surveying data indicating how Loma Prieta Mountain (part of the Santa Cruz range) shifted during each quake.

For last year's quake, scientists gauged ground changes in the region with lasers, satellite signals and even the radio waves from distant quasars. These measurements were then fed into computers.

At the turn of the century, however, surveyors used telescopes to judge the angles between mountaintops and then did all their calculations on paper. Because of these antiquated methods, some scientists view the early calculations with skepticism.

Segall and Lisowski reviewed the old surveying data and plugged them into a computer to recalculate the ground movement during the 1906 event. That quake, with an estimated magnitude of 8.3, moved Loma Prieta Mountain in a direction parallel to the fault, they report in the Nov. 30 SCIENCE. But last year's magnitude 7.1 quake moved the mountain in a markedly different manner, shifting it diagonally toward the fault.

To explain the motion contrast, Segall and Lisowski propose that the two earthquakes ruptured separate faults in the San Andreas system: one that descends vertically and another inclined 20° from the vertical. Seismic evidence collected during the 1989 quake shows that it occurred along a tilted surface that forced the southwest side of the fault to ride up over the northeast side. The recalculated surveying data, along with other evidence, suggest the 1906 event occurred on a vertical fault plane. In this earthquake, the two sides of the fault slid past each other horizontally, with very little movement up or down.

Purely horizontal slippage is characteristic of the San Andreas fault, which absorbs the motion between the Pacific and North American tectonic plates. In fact, seismologists had never seen significant vertical motion during a San Andreas earthquake before 1989. But until Segall and Lisowski reexamined the data for 1906, geoscientists could not rule out the possibility that the earlier quake also included some vertical motion.

Seismologist Hiroo Kanamori of the California Institute of Technology in Pasadena says the suggestion of multiple faults makes sense because of the San Andreas' complex geometry near Santa Cruz. The fault bends there and does not align exactly with the motion of the Pacific and North American plates.

The USGS geophysicists say their analysis raises some critical questions about the "recurrence model" used by the federal government to forecast the probability of earthquakes for specific regions. This model is based on the assumption that the next large earthquake in an area will resemble previous ones. But if the San Andreas near Santa Cruz includes several fault planes, then the recurrence model might be inappropriate.

Seismologists using that model have said they do not expect another strong quake soon along the Santa Cruz Mountain section of the San Andreas. But Segall and Lisowski conclude that the 1989 shock on the tilted fault could have increased stress on a shallow part of a vertical fault. If so, they argue, "the present earthquake hazard in the Santa Cruz Mountains is not negligible."

– R. Monastersky

Mother tongue may influence musical ear

When a Briton and a Californian listen to Beethoven's Fifth Symphony, they may not hear the same thing. New research indicates that people who speak different dialects of a language perceive tonal patterns in strikingly different ways, supporting long-standing speculations that speech characteristics influence the way people hear music.

Diana Deutsch of the University of California, San Diego, set out to investigate a musical paradox she had discovered four years ago (SN: 12/20&27/86, p.391). This phenomenon, called the tritone paradox, occurred when she electronically removed specific "overtones" from a series of two computer-generated pitches separated by a half-octave – an interval called a tritone. Overtones normally help listeners identify the octave of a note; without them, the octave becomes ambiguous, Deutsch says.

In her 1986 study, some people who listened to paradoxical tritone series perceived a rise in pitch from one note to the next, while others perceived a descent. Also, whether an individual thought the second tone was higher or lower depended on the first note. For instance, a person might typically insist that C followed by F sharp was rising but that D followed by G sharp was descending.

Deutsch concluded that most people mentally arrange musical pitches on a circular map, or "pitch-class circle," placing all the notes in positions comparable to the numbers on a clock. However, she observed, the orientation of notes along the circle seems to vary from one individual to the next – for instance, one person might position a particular note at the 12:00 site while another person places it at 5:00. This, according to Deutsch, determines how an individual perceives a paradoxical effect.

But a key question remained: Why do different people orient their mental maps in different ways?

Deutsch believes the answer lies in language. In the new study, she played several ambiguous tritone series to 24 people raised in southern California and then to 12 people raised in southern England. On average, she found, when the Californians thought a particular series rose, the English thought it descended – and vice versa.

The results provide the first demonstration that listeners with different dialects differ profoundly in their perceptions of musical patterns, Deutsch asserted this week at a meeting of the Acoustical Society of America in San Diego. "A relationship between language and music has been hypothesized since ancient times," she told SCIENCE NEWS. "But what hasn't been known is if there is some direct influence of language on music."

"I've concluded very firmly that how you orient this circle of note names . . . is acquired by exposure to speech around you," she adds. Deutsch says her analyses appear to rule out many other potential causes of the tritone paradox, such as differences in age, gender, musical training or mechanics of hearing.

Nor does she believe genetic factors can explain the variation. "It doesn't seem reasonable [to conclude] that we're dealing with two genetic pools [in the latest experiment] if you consider that the population of the Californians was so heterogeneous genetically, including Asian Americans, German Americans" and other ethnic groups. The English group was also fairly heterogeneous, she says.

Deutsch suggests that paradoxical effects might also be heard in real music, perhaps in large orchestras. If so, language-linked perceptions "could drive a person's emotional response," she contends. "An audience in London would want one performance, but an audience in Los Angeles would want something different."

Bruno H. Repp, a linguist at the Haskins Laboratories in New Haven, Conn., remains skeptical. "Whether such effects can be heard in real music, I don't know. But I doubt it," he told SCIENCE NEWS.

At the same meeting, Deutsch reported on another study indicating that the fundamental frequency of a person's voice – the lowest frequency present in a person's voice – also affects how that person perceives the tritone paradox. She measured the fundamental frequencies of nine men and women, most of them college students in San Diego, and then tested their perception of the tritone paradox. In eight of the nine, she discovered a correlation between fundamental voice frequency and how the person perceived various tritone series.

The relationship between Deutsch's dialect findings and the voice-pitch correlations is perplexing. "I don't see why a cultural factor [such as dialect] would have any influence [on the perception of the tritone paradox]," Repp argues. On the other hand, he says, the results "would make sense . . . if different cultural groups used different fundamental ranges in speaking."

Deutsch did not measure the fundamental frequencies of the English/Californian volunteers, but she speculates that further studies may reveal voice-pitch differences between the two groups. She also plans to investigate how people who speak languages other than English react to the tritone paradox, and to compare people raised in various U.S. regions. Ultimately, Deutsch wants to see whether a live orchestra can produce the tritone paradox.

– R.N. Langreth