groups that are small," he says.

Swiss social science and humanities researchers have their own beef with the program. Of the 18 projects recommended by the SNSF to the SRG, three were in the social sciences. None of these was funded, despite the government's previous declaration of social sciences and humanities as one of four priority areas. On 21 December, more than 300 university students, postdocs, and professors sent a letter of protest to Kleiber and his boss, Home Affairs Minister Ruth Dreifuss. The next day, the general secretary of the Swiss Academy of Humanities and Social Sciences, Beat Sitter-Liver, joined two other leaders of Swiss social science organizations in sending another protest letter to Dreifuss. "Social sciences has been relegated to second-class citizenship," contends Keith Krause, a political scientist at the University of Geneva.

Kleiber, also a political scientist by training, says he hopes that parliament will correct that situation this summer by funding four additional centers, one of which is in social sciences. A second (and probably final) call for proposals is expected next year, but some social scientists may pass unless "we are assured that the process will be fair," says University of Geneva sociologist Christian Lalive d'Epinay.

The next time around, Kleiber would like to see a more focused call for proposals and a shorter review process. SNSF Secretary General Hans Peter Hertig acknowledges that there is "certainly room for improvement" in the evaluation procedure, but he disagrees with Schatz's assertion that NCCR will weaken the foundation's support for individual researchers. Individual grants still account for 80% of SNSF's funding.

For Duboule and others involved with the new centers, the program is not just about allocating resources. It's also part of an ongoing effort to improve Swiss science. "We just have to try it and see how it works," Duboule says. "We have to do something; we can't just do nothing." **–MIN KU**

Min Ku is a science writer based in Bern. With reporting by Robert Koenig.

KNOT THEORY

Loopy Solution Brings Infinite Relief

Alexander the Great would sneer. Twenty-three centuries after he slashed through the Gordian knot, mathematicians have finally made their first stab at figuring out how long it takes to untangle a tangle. The unheroic answer, for one key class of knots, is "not forever"—and even that comes with a huge string attached. Still, knot researchers are delighted.

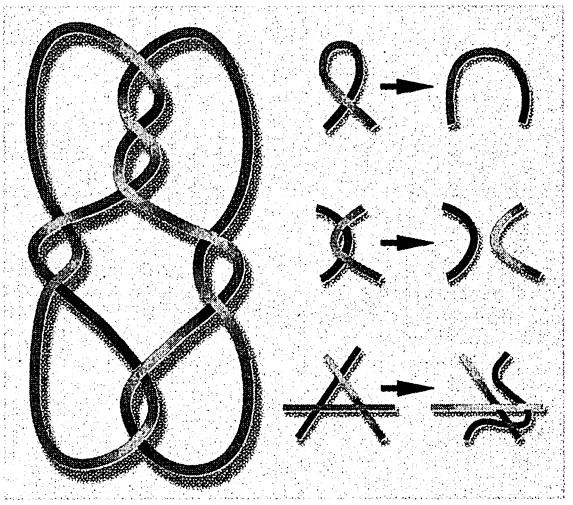


ILLUSTRATION: A. STONEBRAKER

Circle game. In time, three basic maneuvers will reduce a tangle like the one at left to a simple loop.

"People have always wondered if [the unknotting process] was unbounded, and people now know that it is bounded," says Joan Birman, a knot theorist at Barnard College in New York City. "It was a very big problem."

For years, knot theory itself has been in such a tangle that even the most fundamental problems in the field still loom large. "If I hand you a knot, you would hope for some method of identifying it," says William Menasco, a knot theorist at the State University of New York, Buffalo. "The classical problem in knots is to have a complete, nonredundant list of knots, and if you give me a knot, I can standardize it and pick out where in the list it lives." Unfortunately, mathematicians aren't certain that they can do that even for the simplest knot of all: a mere loop of string, also known as the unknot.

This isn't to say that knot theorists have made no progress. For instance, as far back as the 1920s, they had figured out that only three types of motion—the so-called Reidemeister moves—are needed to untangle any knot into a standard, recognizable form. But even with that armamentarium, mathematicians didn't see an obvious way to do the untangling; sometimes the Reidemeister moves made things worse. "They were hoping that the set of moves would make the knot simpler at every step," says Jeffrey Lagarias, a mathematician at AT&T Labs in Florham Park, New Jersey. "The Reidemeister moves do not." As a result, there is no easy way to tell how many moves it would take to untangle a given loop of string—or even whether any finite number could do the job.

Lagarias and Joel Hass of the University of California, Davis, sought to guarantee that unknotting the unknot, at least, does not take forever. Instead of looking at an unknot as a twisted-up loop of string, they treated it as the boundary of a crumpled and distorted disk. They then performed the disk equivalents of Reidemeister moves and translated the results back into the mathematical language of knots. Their conclusion: The number of Reidemeister moves required to untangle any given twisted-up unknot is finite.

Finite numbers, however, can still be ridiculously large. All Lagarias and Hass guarantee is that if a knot crosses itself n times, you can untangle it in no more than $2^{100,000,000,000n}$ Reidemeister moves. In other words, if every atom in the universe were performing a googol googol googol Reidemeister moves a second from the beginning of the universe to the end of the universe, that wouldn't even *approach* the number you need to guarantee unknotting a single twist in a rubber band.

"The [bound] is, of course, enormous and hopeless," Lagarias acknowledges. Still, he says, just showing that a limit exists may inspire future researchers to whittle it down to a reasonable size. (Macedonian swordsmen need not apply.) **–CHARLES SEIFE**

ECOLOGY

Scientists Begin Taming Killer Lake

CAMBRIDGE, U.K.—In an unprecedented and potentially risky experiment, scientists this week began venting carbon dioxide–laden water from the bottom of Lake Nyos in Cameroon. The apparatus is intended to prevent a recurrence of a 1986 eruption that claimed 1800 lives.

The carbon dioxide is released from surrounding volcanic sediment and underground springs. Experts say that about 300 million cubic meters of the gas have accumulated in the waters near the lake's bottom, about 200 meters below the surface. In 1986, an estimated 80 million cubic meters of gas escaped from the lake and flowed down the hillside, smothering residents and livestock in what's known as a "limnic eruption."

Hoping to prevent future such disasters, a team headed by Michel Halbwachs of Savoie University in Chambéry, France, has floated a 3-meter-wide raft in the middle of the lake with a 200-meter-long polyethylene pipe running to the lake bottom. As the water travels upward toward the surface, the carbon dioxide comes out of solution. At the surface, 10 liters of carbon dioxide are released for every liter of water. The result is "a jet 40 meters in height, which can continue without any further input of energy," says team member

Gaston Kayser, speaking from Lake Nyos. "We are very happy with the results."

While applauding the effort, some experts remain cautious. "Everybody is in favor of any attempt to degas the lake. ... This is a great idea," says Sam Freeth of the Geological Hazards Research Unit at the University of Wales in Swansea, U.K. But he says there are "major risks involved" if the experiments are scaled up. Freeth worries that the movement of large quantities of cold, dense water resulting from the removal of the carbon dioxide could generate currents that would trigger another limnic eruption. Freeth urges the French-led team to publish its data so others can review them.

Water safety. Carbon dioxide is gushing from Lake Nyos thanks to equipment first tested in 1995.

The team intends to install four or five more pipes over the next year to degas the lake to acceptable levels. The team will return to France next week and continue to monitor the lake via satellite. Local authorities can turn off the apparatus, which will otherwise run indefinitely, at the first sign of a pending eruption.

–JOHN PICKRELL

POLYGRAPH SCREENING

Panel Seeks Truth in Lie Detector Debate

An expanded polygraph screening program at U.S. nuclear weapons labs begun in the wake of suspected espionage has heated up the perennial debate over the validity of lie detectors. And if testimony at the first meeting last week of a new National Academy of Sciences panel examining the thorny issue is any guide, the truth will be hard to come by. Researchers are, however, exploring alternative technologies, including the use of brain and thermal imaging, to identify what happens in the brain when people lie.

The academy study is funded by the Department of Energy and follows the flap over Wen Ho Lee, a computer scientist at Los Alamos National Laboratory in New Mexico who pled guilty to mishandling classified information after facing allegations of more sinister activities (*Science*, 15 September 2000, p. 1851). The $860,000 study is the first major government-sponsored polygraph study since a 1983 report by the Office of Technology Assessment (OTA) concluded that polygraphs are not an effective scientific method to check for security breaches. A 2-day meeting in Washington, D.C., made it clear why panelists expect the job to take no less than 21 months. "I heard a major disconnect between what different people were saying," says study director Paul Stern.

The panel, headed by statistician Stephen Fienberg of Carnegie Mellon University in Pittsburgh, was confronted immediately with seemingly irreconcilable testimony. Officials from the Energy and Defense departments touted the successes of their programs, while a Department of Energy physicist claimed that polygraph screening does more harm than good. What's more, the panelists heard testimony that experiments aimed at establishing the validity of the polygraph as a generalized screening instrument may be unreliable.

This month, for example, the Department of Defense (DOD) is starting a screening validation study involving 120 subjects—recruited through newspaper ads—some of whom have been trained to pretend they have committed espionage. But panelist Paul Ekman, a psychologist at the University of California, San Francisco, said in a written statement that such research won't yield solid results until the primed subjects are playing for "high stakes"—such as loss of a job.

Other participants questioned the reliability of polygraph use in personnel-screening (as opposed to criminal) cases, because the low base rate of miscreants results in an unacceptably high number of false positive readings. This situation, said Alan P. Zelicoff, a physicist at the Center for National Security and Arms Control at Sandia National Laboratories in Albuquerque, New Mexico, has led to "tremendous cynicism and doubt about the utility of the test in both management and technical staff." He predicts that almost all those who fail the current round of polygraph tests being given at the three national labs will later be found to have been truthful—but with lasting damage to already-low morale.

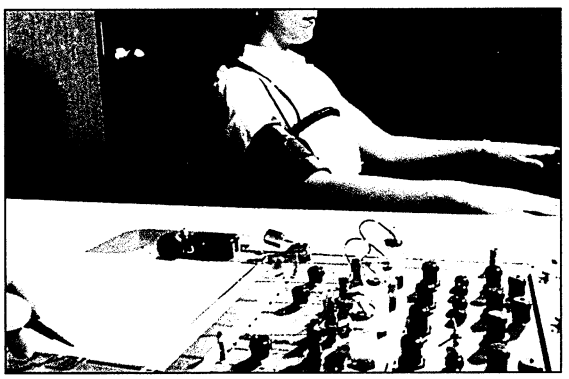
Even practitioners acknowledge that the validity of polygraph tests relies heavily on factors not related to the instrument, such as the training of polygraphers and the nature of the screened population. There is thus growing interest in alternative types of technology. Panel member Richard Davidson of the University of Wisconsin, Madison, says that new approaches now have abundant brain research to draw from—knowledge that didn't exist at the time of the OTA report.

First introduced in the 1920s, the polygraph machine measures four parameters—heart rate, blood pressure, respiration, and sweating. But that physiological quartet doesn't get at what Davidson says is presumably the emotion being measured, namely, "fear of detection." For that, he says, researchers must go straight to the brain: "And if there's one emotion that we have really learned a lot about in the last decade, it's fear."

Animal studies have shown that fear is particularly associated with a brain region called the amygdala. That finding is also borne out by human brain imaging studies using functional magnetic resonance imaging (fMRI) on subjects exposed to facial expressions of emotion. Fear elicits the strongest activation of the amygdala, he says, and it looks quite different from a more generalized anxiety response.

So far there have been no fMRI studies for lie detection. But the DOD is reviewing outside proposals received in response to a broad solicitation for new ways to study the subject. Andrew Ryan, chief of research at the DOD Polygraph Institute, says an fMRI study would ask subjects to lie about something so that researchers can examine patterns of brain activation. "Deception requires more cognitive effort than truth," Ryan points out, so you would expect not just fear but increased cognitive activity.

The DOD is also doing research on thermal imaging, in which the temperature changes caused by variations in facial blood flow during lying is detected with an infrared camera. Other technologies being explored include the use of lasers to pick up muscular, circulatory, and other bodily changes in a process called "laser Doppler vibrometry"; the use of a new voice stress analyzer known as the Vericator; and the monitoring of brain waves, similar to a "brain fingerprinting" system currently in use commercially. All are noninvasive technologies "not even available 10 years ago," says Ryan.



Out of line? Output from a polygraph may fail to detect real emotions behind lying.

Ryan and others hope that this research will usher in an era of new technologies far more adept at ferreting out the truth than what has been available for the past 80 years. "The future machine," he predicts, "will look very different."

–CONSTANCE HOLDEN

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