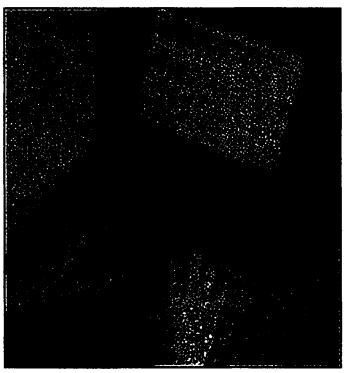
1960s and soon found their way into simple numeric displays on wristwatches and calculators. Now married with powerful silicon electronics, LCDs have grown into a $21-billion-a-year business fashioning screens for everything from laptop computers to cell phones.

The devices use a panel of transistors to control the ability of light to shine through an array of filters. In a typical LCD cell, light enters through a polarizing filter at the bottom of the cell and is twisted 90 degrees by liquid crystalline molecules so that it can exit through a similar filter at the top that is oriented perpendicular to the first. Ordinarily, the rod-shaped liquid crystalline molecules between the filters would stack atop one another all pointing in the same direction. But displaymakers alter that tendency with the help of layers of transparent plastic that sandwich the liquid crystal molecules. During manufacturing, they rub the two plastic layers in perpendicular directions with a velvet roller. This aligns the plastic molecules and causes the liquid crystals near them to line up in the same direction. Because the liquid crystal molecules at opposite ends of the cell are now oriented perpendicular to one another, intervening molecules stack slightly askew, creating what looks like a spiral staircase. This staircase twists light as it passes through, enabling it to emerge from the top polarizing filter. But when an electric voltage reorients the liquid crystal molecules, the light is no longer twisted and so cannot thread its way through both filters. The pixel goes dark. When the voltage is turned off, the liquid crystal relaxes to its original shape.



Cheaper, clearer. Ion treatment may yield better liquid crystal displays.

Although the rubbing step works, it has numerous drawbacks, says Mahesh Samant, a chemist at IBM's Almaden Research Center in San Jose, California. Not only can it damage the transistors on the panel, but the rolling process can introduce tiny contaminants onto the screen and create streaks across it. Both problems regularly force manufacturers to toss out batches containing hundreds of damaged screens.

In hopes of reducing such waste, Samant and his colleagues at IBM's Thomas J. Watson Research Center in Yorktown Heights, New York, set out to develop a noncontact method for aligning their liquid crystals. Four years ago, they tried bombarding various thin surfaces with ions. The technique worked: The ions created tracks in the films that caused liquid crystals layered on top to orient along the same direction.

The researchers didn't rush to tell the world until they had found out whether the technology would work in a manufacturing setting. The Almaden and Watson groups, together with colleagues at IBM's display and engineering business units in Japan, used the new technique to make 15-inch and 22-inch LCD displays that team member James Lacey calls "sharper and crisper" than today's models. The company is now considering using the new process to make all its LCDs.

"It's certainly interesting," says Kimberly Allen, who directs technical and strategic research at Stanford Resources, a company that analyzes display technology and markets. LCD prices have plummeted over the past 6 months as manufacturers have upped their output. That's left LCD makers scrambling for ways to recover their costs, says Allen: "If a new manufacturing step can show even a little bit of cost reduction, that would be helpful to them."

By reducing costs, the new approach could also help LCDs fend off emerging competition from novel technologies, such as organic light-emitting devices (OLEDs), which emit light from thin layers of plastics and other organic materials. If OLEDs can beat back nagging problems with quick burnout, they have the potential to dethrone LCDs as the flat screens of choice. But as the IBM group's work proves, LCD makers aren't sitting around and waiting for the competition to catch up. –ROBERT F. SERVICE

DIGITAL SECURITY

Music Industry Strikes Sour Note for Academics

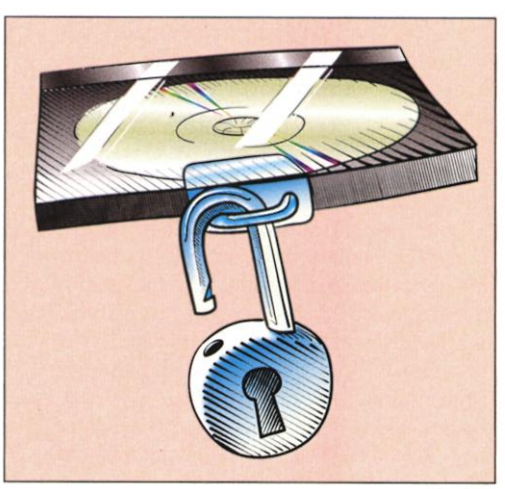
Flush from a courtroom victory over the music-trading network Napster, the music industry is targeting another band of rabblerousers: scientists studying ways to crack digital security technologies. It's following in the footsteps of the motion picture industry, which has sued a magazine for publishing information that could defeat its technology to protect digital videos. At the heart of both cases is the question of freedom of expression under the 2-year-old Digital Millennium Copyright Act (DMCA).

In 1998, some 200 companies banded together to seek a technological fix for the problem of digital music piracy. Their answer consisted of a kind of watermarking, in which a faint digital signature is overlaid on audio bits to mark it as an original and not a copy. Last September, that consortium, the Secure Digital Music Initiative (SDMI), announced a contest to test its copy-protection schemes. Although some hackers and computer science researchers boycotted the contest and its $10,000 prize, saying they didn't want to help the music industry strengthen its copy protection or offer their services so cheaply, Princeton computer science professor Edward Felten and his colleagues at Rice University in Houston and the Xerox Palo Alto Research Center in California accepted the challenge. Last fall, they announced they had succeeded in stripping off the signature without degrading the audio quality (*Science*, 3 November 2000, p. 917).

Forgoing the money, they decided instead to write up the results for presentation last week at the Information Hiding Workshop in Pittsburgh. That's when the music industry's lobbyists moved in. "I sent a courtesy copy to someone at Verance [a company that supplied one of SDMI's watermark technologies]," says Felten, "and a day or two later I got a letter from Matthew Oppenheim, a vice president at RIAA [Recording Industry Association of America]." So did the conference program chair and all of their employers.

The RIAA letter said that any disclosure by Felten and his colleagues would violate a "click through" agreement that was part of the contest. "Any disclosure of information gained from participating in the Public Challenge," Oppenheim added, "could subject you and your research team to actions under DMCA." Oppenheim urged the authors to pull their paper, destroy their data, "and avoid a public discussion of confidential information."

Negotiations proved futile, says Felten, who minutes before his 26 April talk announced that he was pulling out because of a threatened lawsuit "if we proceeded with our presentation or the publication of our paper." That evening, Oppenheim posted his own



CREDITS: (TOP TO BOTTOM) THOMAS BRUMMETT/PHOTODISC; ILLUSTRATION BY C. SLAYDEN

statement on the RIAA Web site insisting that the consortium never intended to sue and that the association "strongly believes in academic freedom and Freedom of Speech." He has declined further comment. In an unusual twist, a French group that cracked three of the four watermarks also presented a paper at the workshop but was never contacted by RIAA. Felten says it's because his team had cracked all four watermarks, including the one chosen to be SDMI's technology.

In the digital video case, the Motion Picture Association of America successfully argued in court that publishing a few lines of code that remove the encryption from DVDs is prohibited by a clause in the DMCA that outlaws disseminating information that aids circumvention of technological copy-protection measures. The appeal of that ruling by a computer magazine, *2600*, is being heard this week in federal circuit court in New York.

Jessica Litman, a law professor at Wayne State University in Detroit, Michigan, says the Felten case highlights the overbroad nature of the act. "One of the things that is surprising is that the free speech and academic freedom implications are coming up so quickly," she says. Princeton University president Harold Shapiro believes that the music consortium's actions could have a chilling effect on researchers. "If it is interpreted narrowly, then it might not be a problem," he says. "But if interpreted broadly, there would be very serious concerns for academic freedom."

Felten says the researchers had hoped that the industry would learn from the results and improve its security measures. "Instead they tried to suppress it," he says. He worries that RIAA's actions will inhibit "a large body of research ... [with] very serious consequences for progress in computer security."

–DAVID VOSS

ORIGINS OF BSE

Intriguing Clues to a Scrapie–Mad Cow Link

PARIS—Apart from scandals involving the royal family, few stories are better at firing up the British press than the latest in the sad saga of bovine spongiform encephalopathy (BSE), or "mad cow disease." In the 27 April issue of *The Independent* newspaper, a headline suggested that the mystery of BSE's origins was solved, proclaiming that "Tests Show BSE Caused by Infected Sheep." The truth is far more complex, say scientists, who nonetheless laud the unpublished research described in the article as a possible step toward understanding how the puzzling disease got started.

The human form of BSE, variant Creutzfeldt-Jakob disease (vCJD), has killed nearly 90 people in the United Kingdom and three in France. Uncertain about how many more people may be incubating the invariably fatal disease, scientists are anxious to understand the relation between BSE, vCJD, and scrapie, which afflicts sheep. All three fatal neurodegenerative diseases have been linked to abnormal proteins called prions.

Scourge? Scrapie-BSE link may get a boost.

The new work is by a team led by veterinarian Danny Matthews, chief of prion disease research at the U.K.'s Veterinary Laboratories Agency in Weybridge. In July 1999, his team injected the cerebrums of 10 calves with brain tissue from sheep that had died from scrapie before 1975, well before the BSE epidemic got going in the early 1980s. A second group of calves was injected with brain matter from sheep that had died after 1990. So far, one calf from each group has died from a neurodegenerative disease resembling BSE. However, Matthews told *Science*, tests to unmask the disease-causing agent are still under way.

If it turns out that the scrapie agent is the killer, says prion researcher Moira Bruce of the Institute for Animal Health in Edinburgh, it would strengthen the hypothesis that BSE arose from cattle feed that included ground-up sheep carcasses. But, Bruce cautions, "it would not prove" the link. Indeed, says epidemiologist Peter Smith, acting chair of the U.K.'s Spongiform Encephalopathy Advisory Committee, "it is going to be very difficult to sort out the origins of the epidemic."

Last October, the so-called "scrapie hypothesis" was dismissed in a major report from a U.K. panel chaired by Lord Andrew Phillips (*Science*, 3 November 2000, p. 911; www.bse.org.uk). The report threw its weight behind the hypothesis that BSE arose from a spontaneous mutation in cattle, creating a new form of prion. Among the evidence for this scenario, it cited experiments by U.S. Department of Agriculture scientists showing that while some cattle infected with scrapie-infected brain extracts displayed neurological symptoms, these did not resemble BSE. Matthews speculates that the U.S. experiments may have used extracts harboring different scrapie strains from those in his experiments.

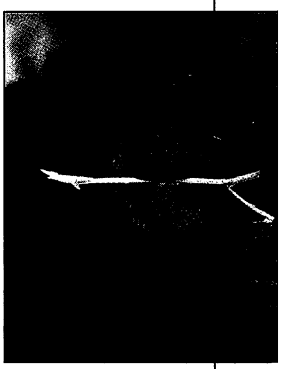
Several scientists believe the Phillips report discarded the scrapie hypothesis too

ScienceScope

Life-and-Death Decisions Heads may soon roll at Paris's Pasteur Institute, a topflight research center that has produced eight Nobel laureates in the past century. Over the next few months, director-general Philippe Kourilsky and the Pasteur's scientific council will decide whether to ax several research units that failed to pass muster in a recent evaluation.

When Kourilsky took the helm in January 2000, he promised to subject the institute's 39 research units to much tougher scientific scrutiny and to limit the terms of their directors (*Science*, 28 January 2000, p. 567). In February, the scientific council put 22 of the units under the microscope: Fourteen passed with flying colors, and several others were renewed pending changes in their research priorities. But four units received a thumbs down. Although Pasteur officials decline to name the failing labs, Kourilsky told *Science* that "there will be some closures."

Chimp Reprieve Europe's only chimpanzee research facility will be closed. Dutch officials last week said they will follow an expert panel's recommendation to end chimp research at the Biomedical Primate Research Center (BPRC) in Rijswijk.



Animal-welfare groups have criticized the facility for its cramped cages and obsolete facilities. And the Royal Netherlands Academy of Arts and Sciences panel—led by cancer researcher Anton Berns of the Netherlands Cancer Institute in Amsterdam—found that few academic researchers were using it. In 1999, for instance, just seven of the center's 100 chimps were involved in experiments. The panel said that the animals should be retired to zoos or sanctuaries, and that researchers needing chimps could look to the United States for subjects.

Dutch officials say research on the BPRC's 1000 rhesus monkeys will continue and have not yet set a timetable for ending the few ongoing chimp experiments.

Contributors: David Malakoff, Andrew Lawler, Michael Balter, Gretchen Vogel

CREDITS: (TOP TO BOTTOM) M. BAYLIS; TAD MOTOYAMA/LOS ANGELES ZOO/AP