

Fight Erupts Over DNA Fingerprinting

A bitter debate is raging over how the results of this new forensic technique are interpreted in court

WHEN DNA FINGERPRINTING WAS FIRST introduced in U.S. courts in a 1988 rape case in Florida, it was heralded as a tool of stunning precision, the greatest forensic advance since the advent of fingerprinting itself. After all, when it comes to identifying a murderer or rapist, what could be more definitive than a comparison of his DNA with DNA obtained from blood or sperm samples left at the crime scene? Indeed, proponents of "DNA fingerprinting" have claimed that the probability of two DNA samples matching by chance is minuscule—citing figures like 1:500,000 or 1: 738,000,000,000,000.

But on page 1745 of this issue of *Science*, Richard Lewontin of Harvard and Daniel Hartl of Washington University, two of the leading lights of population genetics, assert that such statements are "terribly misleading" and "unjustifiable"—there are simply no data on genetic variation among ethnic groups to support those claims. And until such data are collected, which could take up to 10 or 15 years, they argue that these probability statements should not be allowed in court. They have the support of numerous colleagues who have, like Lewontin and Hartl, taken to the courtroom to testify as expert witnesses for the defense in a variety of criminal cases. And the debate, which involves some arcane issues in population genetics, has become decidedly nasty.

Proponents of DNA fingerprinting—the FBI, prosecuting attorneys, and their many scientific supporters, who include Ranajit Chakraborty of the University of Texas, Kenneth Kidd of Yale University, and Thomas Caskey of Baylor College of Medicine—concede that all the data are not in but insist that their approximations are close enough. "It makes absolutely no difference to me if the number is 1 in 800,000 or 1 in 5 million," says Kidd, adding that it probably doesn't matter to a jury either.

Nonetheless, they fear that, esoteric as this

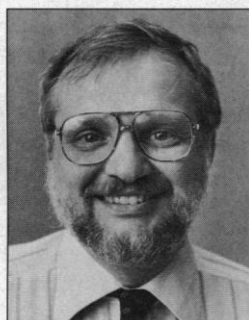
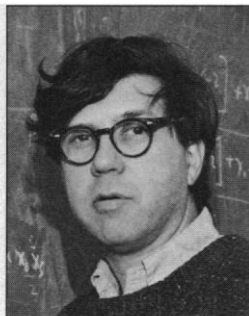
argument appears, Lewontin and Hartl's article will persuade judges to throw DNA evidence out of court and derail the prosecution in numerous cases. It is not an entirely idle fear; already, after hearing testimony from a cadre of population geneticists, a half-dozen courts recently refused to admit DNA evidence on the grounds that the probability calculations are not generally accepted.

The advocates of this new technology are not taking the attack lying down. Once they got wind in October that Lewontin and Hartl's article was coming out in *Science*, a few, including Caskey, Kidd, and James Wooley, an assistant U.S. attorney in Ohio, did their level best to see it was not published—at least not without a rebuttal. Chakraborty and Kidd have indeed written a rebuttal, which also appears in this issue, on page 1735.

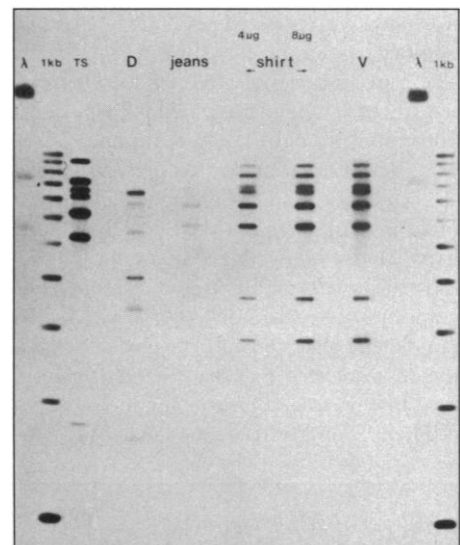
Since then, the rhetoric has, if anything, escalated; tempers are flaring, charges and countercharges are flying. The DNA fingerprinting advocates say that under the guise of an academic debate, Lewontin and Hartl are not just trying to improve the way the results of this powerful new technology are presented in court. They are really trying to keep it out of court entirely.

Lewontin and Hartl hotly deny that this is their intention. Hartl calls it part of a "disinformation campaign. We are not saying that at all. We say fix it and use it. If the methods of calculation were changed so they could be justified, I would be delighted to testify for the prosecution." What's more, he and Lewontin charge that the FBI and its supporters have

launched an intimidation campaign designed to muzzle them. They accuse *Science* editor Daniel Koshland of caving into political pressure by commissioning the Chakraborty-Kidd rebuttal, a charge Koshland denies (see box on page 1722). Hartl says he had no idea just how nasty a scientific disagreement could get. "Being continually subjected to ad hominem attacks and in-



Richard Lewontin (top) and Daniel Hartl.



Compelling evidence. Bands indicate that blood on defendant's shirt came from the victim (V), not from the defendant (D).

timidation, like I have been, is emotionally draining and harrowing and a decidedly unpleasant experience."

Dispassionate observers, who are few and far between, say that the technical arguments on both sides have merit. "They are all smart people," says James Crow, a human geneticist at the University of Wisconsin. To Crow and others, like Francisco Ayala, a population geneticist at the University of California, Irvine, the debate is not about right and wrong but about different standards of proof, with the purists on one side demanding scientific accuracy and the technologists on the other saying approximations are good enough. "This is a religious argument," says one geneticist who wants to stay out of the fray and thus seeks anonymity. "We are talking about matters of faith that are not likely to be settled by reason, which is why they are at each others' throats."

No one in either camp questions the ultimate power of this technology. In fact, Lewontin and Hartl say that, "appropriately carried out and correctly interpreted ... DNA typing is possibly the most powerful innovation in forensics since the development of fingerprinting." In their article, they put aside questions of whether the samples actually match and how reliably the tests were done, both of which have drawn fire in the past. Rather, what they are worried about is the next step, when the prosecutor presents a vanishingly small probability that a DNA sample taken from a crime scene could match that of a random individual. That is a crucial piece of information in the courtroom, they say, for it tells the jury how much weight to give to this new type of scientific evidence.

Typically, the crime lab will have analyzed the two DNA samples at four or five distinct

tive sites, or loci, that contain a variable number tandem repeat, known as a VNTR. These are stretches of DNA in which a short sequence is tandemly repeated perhaps 20 to 100 times, though the exact number of repeats varies from person to person. Unlike classic genetic markers, which usually have a mere handful of variants (alleles), VNTRs can have 100 or so, making it theoretically possible to piece together a unique DNA "fingerprint" for each individual. If two DNA samples are alike at four or five of these loci, the odds are very high that the DNA is from the same person—but how high?

The FBI and other crime labs now calcu-

late the probability by determining how frequently each VNTR pattern occurs in the relevant population, looking at either a Caucasian, black, or Hispanic database. Assuming that all the markers are inherited independently, the forensic scientist then multiplies the frequencies of the markers to calculate the probability of any individual having that particular combination. Almost always, it's a tiny number, like the much-quoted 1:738 quadrillion.

Wait a minute, say Lewontin and Hartl, who argue that a number of unsupported and unsupportable assumptions underlie that calculation. They say the current

method assumes that blacks, Caucasians, and Hispanics are homogeneous populations undergoing random mating—in other words, people are not selecting each other on the basis of their genes. But this, they contend, ignores "a considerable body of evidence" indicating that each of these groups is actually made up of multiple subpopulations—and that each of these subgroups is genetically diverse.

Because VNTR markers are relatively new, little data exist on their distribution in different populations. So for evidence, Lewontin and Hartl cite studies done with classical genetic markers, such as genes cod-

Was *Science* Fair to its Authors?

Both in courtroom testimony and in an article in this issue of *Science* (see p. 1745) questioning the way DNA fingerprinting techniques are being used in court, population geneticists Richard Lewontin and Dan Hartl have taken on the forensic science establishment. Not surprisingly, their fellow geneticists who are proponents of DNA fingerprinting, as well as the users of the new technique at the Federal Bureau of Investigation, have struck back, charging that Lewontin and Hartl are, in essence, trying to hang them on a technicality to get DNA typing evidence thrown out of court.

The response of the two critics? Both charge that their opponents—among whom they now include *Science* editor Daniel Koshland—are hitting below the belt. The accused deny all charges.

The tussle began when word got out that Lewontin and Hartl were publishing an article in *Science* criticizing the calculations used to determine the probability of a chance match between two DNA profiles. Proponents of the technique assert that such odds are likely to be minuscule. But Lewontin and Hartl are not so sure, arguing that such calculations can be off by two or more orders of magnitude.

Before long, copies of their prepublication manuscript, which was submitted as defense evidence in a case in Oregon, were circulating throughout the genetics and forensic science communities. Geneticists Kenneth Kidd of Yale, Ranajit Chakraborty of the University of Texas, and Thomas Caskey of Baylor College of Medicine, all of whom have testified for the prosecution, obtained copies before attending the International Congress of Human Genetics in Washington, D.C., in early October, where the paper created quite a stir.

Says Kidd: "I felt publishing the article would create a very serious problem in the legal system, and that that was their intent." His fear was that defense attorneys who want to block the admission of DNA evidence in court would play on the fact that the critique had passed peer review in a top scientific journal. Further, he says, "I thought there were major scientific points on which they were wrong or on which there are very legitimate alternative viewpoints, and that for the article to appear without some sort of rebuttal was inappropriate." In fact, Kidd and Caskey felt so strongly that they cornered one of *Science*'s editors at the meeting, urging her to pass on their concerns to Koshland.

Academic scientists were not the only people concerned about the paper. Rumors abound that unnamed people from the FBI said

they would make sure the article was killed. John Hicks, director of the FBI's Crime Laboratory, says he heard the rumor, questioned his staff, and could find no evidence for it. And editor Koshland insists that he heard from no one in the FBI or in the government; he only heard complaints from academic scientists. Hartl, though, did get a call in early October from James Wooley, an assistant U.S. attorney in Ohio who was one of the prosecutors in a case in which Lewontin and Hartl testified for the defense. Says Wooley: "I told him I thought the paper would be misconstrued, that it will confuse and mislead—and that with the credentials of Drs. Hartl and Lewontin, it would have an impact on cases disproportionate to its significance." That phone call prompted Lewontin to write Wooley, blasting him for trying to suppress the article and intimidate a private citizen. "It is always alarming when agencies of the State...are used as intimidating devices against citizens who oppose a stated policy of the government," Lewontin wrote. In a recent letter to Koshland, Joyce George, Wooley's boss, insists that no intimidation was intended, saying that Wooley was simply expressing his opinion, as are Lewontin and Hartl, on a matter of scientific and legal concern.

Meanwhile, Koshland, alerted to at least some of this controversy, took a second look at the article, which by then was in galleys. He was disturbed that the data did not support the paper's conclusions and called Lewontin to ask him for revisions. Coming shortly after Wooley's call to Hartl, Koshland's call was not well received. Lewontin says he told Koshland that if there was any attempt to hold up the paper or withdraw it, "it would be met with the biggest stink he had ever heard."

Koshland denies that he was trying to do either and says he would not be intimidated by the FBI or by authors threatening to go public. He says that asking for revisions is routine practice, and both authors agreed to it. Koshland concedes, however, that it would have been preferable to have caught what he calls errors in the paper earlier in the editorial process.

Lewontin also takes issue with Koshland's decision to commission a rebuttal by Kidd and Chakraborty for the same issue. "Pure politics," Lewontin says, adding: "I think it is quite extraordinary that an editor would go out and hire two guys to write a rebuttal" after the article had been peer reviewed and accepted.

Koshland defends his actions as entirely proper, noting that *Nature* publishes rebuttals frequently. "I did it to give a more balanced view of the subject. I was trying to be fair." Neither Lewontin nor Hartl is buying the argument, though. ■ L.R.

ing for blood groups or for particular enzymes. Among Caucasians, they say, those markers show that the frequency of some genes differs considerably among different ethnic groups, such as Poles and Italians. And that ethnic variation is likely to be maintained, Lewontin and Hartl point out, because demographic evidence shows that immigrants and their descendants "tend to marry the girl or boy next door" rather than form some "biological melting pot." Thus, there is no reference "Caucasian" database that would be meaningful for all these different subgroups. Although these studies were done for classical markers, Hartl and others, like Ayala at Irvine, suspect that this ethnic diversity would be even more pronounced at VNTR loci, since they mutate quickly and, because they are not functional, are not subject to natural selection.

The situation is almost as messy for blacks as it is for Caucasians, and it is even worse for Hispanics, a classification that Lewontin calls a "nightmare." The Hispanic designation is a "biological hodgepodge," they say, including people of Mexican, Puerto Rican, Guatemalan, Cuban, Spanish, and other descent, some of whom are mostly pure Indian, while others are mostly pure European, and still others have considerable African ancestry.

The upshot, Lewontin and Hartl argue, is that crime labs can't simply look at VNTR allele frequencies in some "reference" database and then multiply them. A VNTR combination that is very rare in the reference database might, for example, be much more common in the suspect's particular subgroup, thus raising the chances that he will be incorrectly identified as the criminal. The estimate may be off by two or more orders of magnitude, Lewontin and Hartl say—and it could be biased either for or against the defendant.

The only way to come up with realistic probability estimates using the existing method, they conclude, is to look at the allele frequencies within each subgroup and then multiply them. But data on genetic variation among ethnic subgroups simply do not exist—and getting them could take 10 to 15 years, Lewontin concedes. He and Hartl are adamant that the current methods for calculating the odds should not be used "until there are data to back them up," as Hartl says. However, they point out, the current methods are not the only possibility. In their article they discuss two admittedly less powerful alternatives, such as simply reporting that this particular DNA pattern was not found in a database of, say, 2000 individuals. The tradeoff, though, is that the

prosecution would have to settle for much larger (and to a lay jury, less convincing) probability estimates than are now claimed.

Chakraborty and Kidd—who have both testified for the prosecution in criminal cases—contend that Lewontin and Hartl are counting angels on the head of a pin; engaging in a fascinating if esoteric academic debate that has almost zero relevance to the use of DNA fingerprinting in court. Similarly, one of their staunch supporters in the FBI, John Hicks, director of the Crime Laboratory, calls the whole dispute "much ado about not very much."

Sure, Chakraborty and Kidd concede, there are genetic differences among subgroups, but they are not as great as Lewontin and Kidd make out. "There is overwhelming evidence that no genotype is common," says Kidd. And even if huge undetected genetic differences do exist, they say, the procedures used by the FBI and the testing companies are robust and conservative enough to compensate for them. They cite, in particular, a procedure known as "binning" that is used to determine whether two alleles actually match and is intentionally designed to favor the defendant.

Lewontin and Hartl, in turn, have a rebuttal for each of Chakraborty and Kidd's complaints. For instance, they ask, how can Chakraborty and Kidd say the current procedures are conservative enough when there are simply no data that would allow them to estimate the magnitude of the error?

But while the debate between the two sides now shows no sign of abating, there is a way out of the morass, if either side will compromise, says observers like Ayala and Crow. "Conceptually, Lewontin and Hartl are right," says Ayala. I don't have a hunch about how to predict how much interpopulation variation there is. But in practical terms, there is a middle ground." Ayala agrees with them that the current statistical methods could result in "tremendous" errors and should not be used without more empirical data. In fact, he was one of the scientists who urged the National Academy of Sciences to undertake a study on just this issue—a study that has now been under way for nearly 2 years. But resolving the question does not require the definitive study of ethnic subgroups that Lewontin and Hartl suggest, he says. Rather, with a more modest effort over the next few years, it should be possible to get enough data to make probability statements

that should be useful. "Lewontin and Hartl say until we have the full information, we can't make that calculation. But we live in an imperfect world. In most cases, if you can make a statement within an order of magnitude, you are probably better off" than not making one at all, says Ayala.



Ranajit Chakraborty

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Crow, who calls Lewontin and Hartl "perfectionists," suggests another alternative. "Rather than embark on a detailed study of human population structure, although this would be interesting and justified in its own right, I would think that adding more loci to the battery would be more cost effective. Even a small number of additions would soon bring the probabilities of a chance

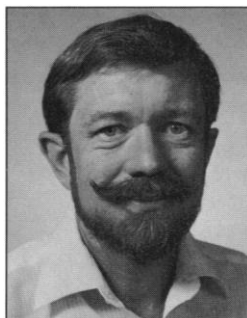
match very close to zero."

Nearly everyone, including Lewontin and Hartl, agrees that many of these statistical questions may be moot within a couple of years anyway, with the expected introduction of even more powerful DNA techniques capable of uniquely identifying individuals, like the promising new digital approach just developed by Alec Jeffreys at the University of Leicester, England.

In the interim, the courts will be grappling with conflicting testimony from an ever-growing cadre of expert witnesses. Under the so-called Frye standard, the courts may decline to admit scientific evidence if it is not generally accepted within the scientific community. These two articles seem likely to reinforce the notion that the community is indeed divided.

Even so, Hicks of the FBI and Philip Reilly, a geneticist and lawyer at the Shriver Center for Mental Retardation who tracks this issue, expect only a temporary derailment. DNA fingerprinting has been accepted in several hundreds cases and, despite the recent setbacks, says Reilly, there "still seems to be a major trend toward accepting it." He predicts that "at worst, there will be a blip, 6 months or 2 years, when trial courts are reluctant to accept it" because of the statistical questions. "There is absolutely no doubt DNA is here to stay."

Within the next couple of weeks the National Academy of Sciences will weigh in on the matter with its long-awaited report on DNA fingerprinting. The panel spent months debating this topic, during which time their views evolved considerably, says Johns Hopkins geneticist Victor McKusick, who chaired the panel. Without divulging the report's conclusions, he says that it will shed some light, rather than just heat, on the subject, perhaps providing the definitive word the courts can turn to. ■ LESLIE ROBERTS



Kenneth Kidd

YALE