DNA's identity crisis

If defense attorney Bicka Barlow and a growing group of skeptical lawyers and scientists are right, we have built our justice system's use of DNA evidence on statistical sand.

BY CHRIS SMITH
PHOTOGRAPH BY NADER KHOURI

IN THE FALL OF 2006, A GRISLY MURDER CASE LANDED ON BICKA
Barlow's desk, one that had gone unsolved for more than 30 years. As the resident DNA expert in the San Francisco Public Defender's Office, Barlow handles the genetic evidence for most files that come through the door. The accused, John Puckett, was an ex-felon who, by all accounts, had been living a quiet life for the past two decades. He was an old man by now, and his health was failing; if convicted, he would probably die in prison.

The California Department of Justice had identified Puckett through a "cold hit," in which his DNA was matched to the long-ago crime scene through a search of the state's criminal offender database. The San Francisco Police Department was extremely excited about the case: It was the second-oldest cold case in city history, and solving it was made possible, a triumphal press release declared, by advances in DNA technology and a state grant aimed at increasing cold-hit prosecutions. After examining the particulars of the case, Barlow realized this just might be the opportunity she had been waiting for.

A baby-faced, 46-year-old molecular biologist turned lawyer, Barlow has worked as a defense attorney for the past 13 years. During that time, she, along with a small but growing group of scientists and lawyers, has seen convincing evidence that a DNA match isn't anywhere near as foolproof as TV shows like *CSI* and the criminal justice system make it out to be.

Used properly, DNA evidence has the power of God's right hand, descending from the clouds to smite the wicked or spare the innocent. It has helped catch serial killers like Wichita's BTK Strangler and, through the Innocence Project, freed more than 200 wrongfully convicted people from prisons across the country. In the strongest DNA cases, the DNA from the crime scene matches that of the accused at all 13 of the locations (out of the millions that make up an individual's genome) that experts have settled on as an efficient marker of identity. Only identical twins, it's generally agreed, share all 13, so the chances that someone else has your exact DNA profile
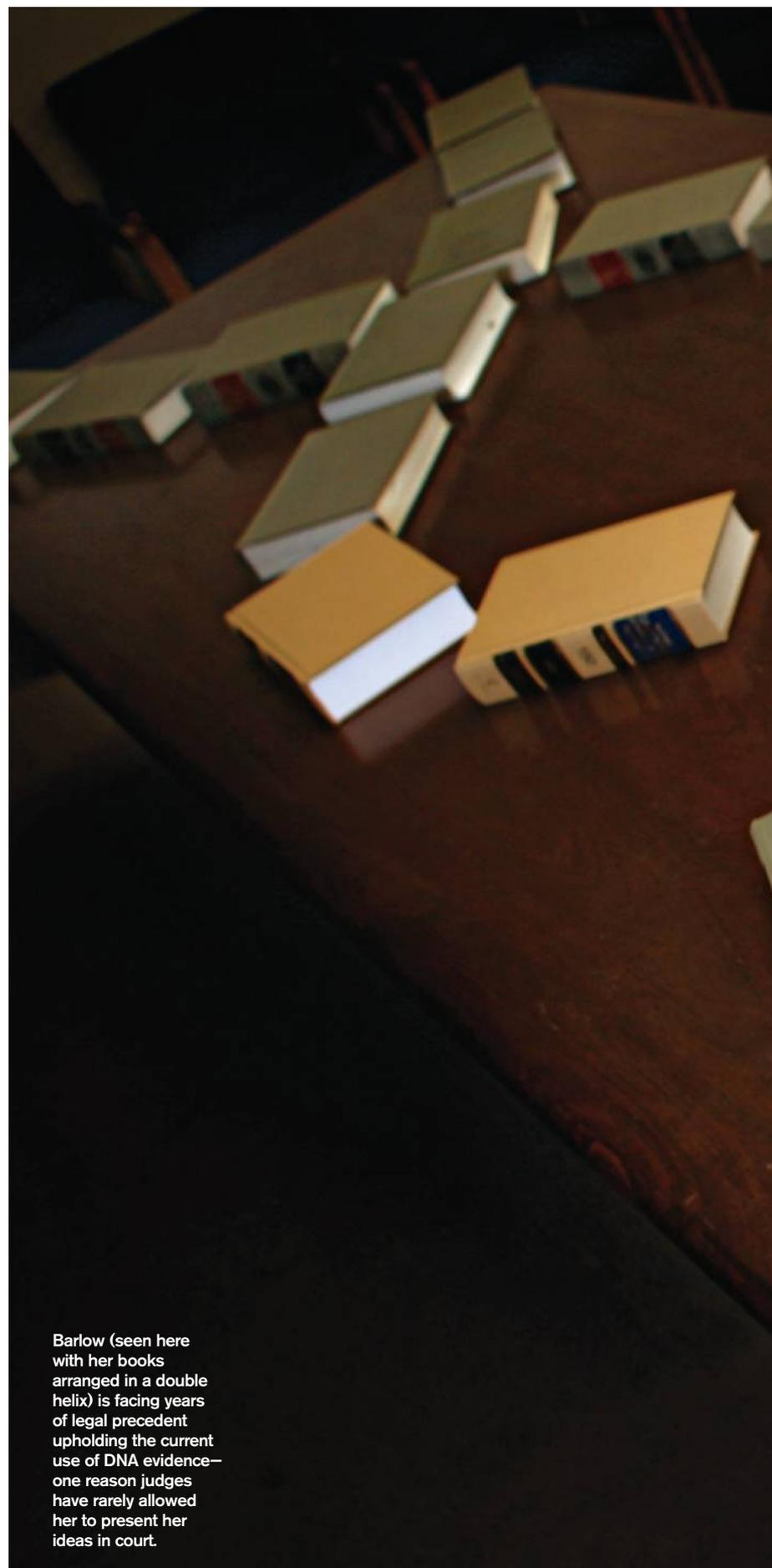
Barlow (seen here with her books arranged in a double helix) is facing years of legal precedent upholding the current use of DNA evidence— one reason judges have rarely allowed her to present her ideas in court.

on those locations are virtually prohibitive: about one in a trillion. Even these stratospheric odds can lead to a wrongful conviction, at least in theory, but our justice system long ago decided that they represent an acceptable level of risk. It's when the DNA match falls below 13, which happens in many cases, that the legal wrangling begins. In some jurisdictions, crime labs only test at nine locations. In other cases, the DNA sample is old or degraded enough that not all 13 locations can be read. Experts call this a partial profile, meaning that the two samples match, but only at a lower level.

In essence, the lower the match, the higher the odds that someone else shares that DNA profile, and that you've snagged the wrong person. The FBI has calculated those odds at various levels—they're the numbers that the O.J. Simpson case burned into every viewer's mind and that are used routinely to give jurors a sense of the risk of a coincidental match. At a match of 10 locations out of 13, depending on the subject's ethnicity, the odds that someone else has the same genetic profile might be one in 10 billion; at 6, they might be one in a few million.

Barlow is among a large number of defense attorneys and scientists who have always been wary of using low-level matches to convict people, especially in the absence of other convincing evidence. But a few years ago, data surfaced to suggest that coincidental matches at these lower levels are far more common than we've been led to believe. That means the odds that a person other

Barlow's client, John Puckett (right), confers with his lead attorney, Kwixuan Maloof, during his murder trial in early 2008. The crime in question occurred 36 years ago, but Puckett was identified in 2004 through a DNA search of the criminal database. The match, however, was weak.

than the accused (potentially the real murderer) shares that DNA—odds that jurors hear in court—may be off by orders of magnitude. Barlow is especially concerned about using low-level DNA matches in cold-hit cases, because the likelihood of a false match increases statistically. In Puckett's case, his DNA matched at only five and a half locations, reducing those vertigo-inducing odds of one in a trillion to one in 1.1 million, according to the SFPD crime lab's calculations. That number still sounds fairly high, but if Barlow and her colleagues are correct about cold hits, the more realistic odds of a false match could be something like a startling one in three.

Starting in January 2009, California (along with 11 other states) will widen the scope of its DNA collection, drawing samples not just from anyone who is convicted of a felony, as the state does now, but also from anyone *arrested* for a felony. The genetic profiles will be dropped into the state's criminal offender database and eventually the FBI's much larger CODIS database, which at last count held more than five million profiles. Unquestionably, these databases are powerful crime-fighting tools. But if the statistics jurors hear in court are wildly overstated, then relying on DNA in cold cases like Puckett's is an extremely dicey proposition—one that could well land innocent people in jail.

It hasn't been easy to get a hearing for these concerns. Judges, prosecutors, and FBI mandarins have fought this movement every step of the way, denying access to crucial information that would allow further research on
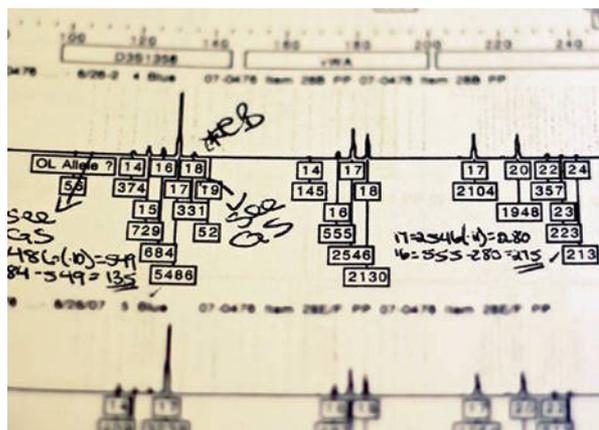
This is a computer printout of a DNA test result. Each cluster of peaks above the line represents one locus. Pictured here are three of the nine loci tested.

the subject, and refusing to allow these ideas to be introduced at trial. After prying loose critical evidence in Arizona for a case back home, Barlow was even told by that state's Department of Public Safety (DPS) to quit disseminating it or she would face vague but serious repercussions, which she assumes could mean the loss of her California law license.

But Puckett's case, she thought, might finally break it all wide open. It would be tough to drum up sympathy for her client, a lifelong ne'er-do-well with a long criminal record. His DNA, though, matched at such a low level that she thought the judge would allow her to raise these broader issues. As Barlow told me months before the trial, "This is one of the weakest DNA cases I've ever seen."

It all began seven years ago in Phoenix. Kathryn Troyer, an analyst at the Arizona DPS, was doing a routine check of the state's criminal offender database and noticed that two of the profiles matched at nine locations, or "loci," in scientific parlance. She had seen plenty of complete, 13-locus matches, as the databases are filled with duplicate profiles (some criminals have records under numerous aliases). This match, though, was different: One man was white, the other black. They had different names and birthdates and didn't appear to be brothers.

According to the FBI's own population frequency tables—the ones crime labs generally use to calculate DNA rarity—the chance of finding a coincidental nine-locus match in the general population is about one in 754 million for whites, and one in 561 million for blacks, depending on certain genetic variables. (This number is called the random match probability, or RMP, and it's the coincidental-match statistic that jurors usually hear in court.) In the Arizona database, which contained only 10,000 profiles at the time, there shouldn't have been a single coincidental match, but there it was. When Troyer presented her findings at a forensics conference later that year, along with photos of the men, the FBI brain trust told her that it was nothing to worry about, and to let it drop.

It might have ended there, if not for Barlow. After hearing about these anomalies, she called Troyer in Phoenix in 2005. In the interim, Troyer explained, she had found more matches. How many? As Barlow

In the Arizona database of 60,000, Barlow was expecting to hear that there were 10 to 20 DNA matches. But an analyst at the department found 90. "I almost fell over when I heard that," Barlow says.

remembers the conversation, Troyer answered, "I don't know, I lost count." Barlow asked Troyer to write a letter documenting the matches; a week later, she instead got a letter from Troyer's boss, who politely but firmly declared the conversation over.

But Barlow wasn't about to go away. She's a fighter by both nature and nurture: Her mother is a Holocaust survivor with a distinct take on the world that she passed on to her daughter. "I was taught that the power of the government is something to be skeptical about," Barlow says. "You have to stand up and make yourself heard." Growing up in Berkeley in the late '60s also helped. "I remember going out to the Polo Fields [in Golden Gate Park] for peace marches, sitting on my father's shoulders," she says.

So she decided to subpoena the state of Arizona for access to Troyer's database searches. The information they contained was relevant, she believed, to a case she was working on. That hearing in Phoenix in the fall of 2005 was full of surprises. By that time, the database had grown to 60,000. When Barlow asked Troyer how many pairs of nine-locus matches she'd found, Troyer answered matter-of-factly, "Approximately 90."

"I almost fell over when I heard that," Barlow says now, with a laugh. "I was thinking she had 10 matches, or 20. That would have been huge, right?" While the judge refused to order the release of the full genetic profiles for each matching pair (which would have included all the genetic traits routinely tested for each person, instead of just a summary of those that matched), he did force Arizona to run a search of the DNA profiles for Barlow. The end result, with yet another 5,000 profiles in the database: 122 matching pairs at 9 loci, and 20 matching pairs at 10 loci. That meant more than 200 people could be misidentified and arrested for crimes they hadn't committed.

Arizona, it turns out, wasn't a fluke: Searches soon revealed similarly disquieting numbers in other state databases. In 2006, for example, a Chicago judge ordered a search of the Illinois database, which turned up 903 pairs that matched at nine loci or above, out of 220,000 people. A search of Maryland's 30,000-person database reportedly found 32 pairs at nine or more loci. Clearly, something was going on. As Barlow put it in court that day in Phoenix, the FBI's population-rarity statistics are "only an estimate, and the estimate is wrong."

Barlow and others believe the problem lies with the FBI's model for calculating the random-match probability. To get this number, crime-lab analysts plug the suspect's genetic profile into population tables drawn up by FBI scientists and other researchers. There are different tables for every ethnic group—a certain trait might be more rare among Caucasians, say, than among Asians—and they are assumed to offer an accurate picture of the statistical frequency of genetic profiles in that population. But since the tables are composed of only about 200 people each, experts say, they may be

drastically underestimating the true frequency of many genetic combinations.

Even though the FBI brushed off Troyer's initial concerns, its top researchers studied the problem and eventually concluded that everything was fine. Purely as a statistical matter, they declared, all those matches were actually to be expected in such a large database.

But many experts aren't convinced. The idea that this many matches were expected is goalpost shifting on a grand scale, says Erin Murphy, an assistant professor at UC Berkeley's law school who specializes in forensics. "The story before Arizona was that a nine-locus match was, like, a one-in-a-trillion thing," she says. "Now the story is, we expected that all along."

It *is* possible to account theoretically for so many partial matches, explains Laurence Mueller, a population geneticist at UC Irvine and a longtime DNA watchdog, once ethnicity and sibling relationships are factored in. (People generally have more DNA in common with relatives and those in their own ethnic group.) But for that to be true, Arizona's 65,000-person database would have to be holding between 1,000 and 3,000 full brothers or sisters, Mueller argues in a groundbreaking recent article for the *Journal of Genetics*. That's not very likely, he says, so there might well be some matches—quite a few, perhaps—that the genetic population tables are failing to account for. He can't say anything definitively, however, because he can't get his hands on the full genetic profiles that would allow for a thorough examination. That's why the judge's decision to deny access to the full Arizona database was so critical. Without that information, what looks like a coincidental match might well just be someone's big brother, or vice versa.

The lack of access to databases far and wide isn't likely to change. The FBI claims that providing the data to outsiders would be so time-consuming that the business of crime fighting would grind to a halt, and that it isn't possible to release the information on the profiles without compromising privacy rights. Both arguments are bunk. State crime labs upload profiles to the FBI's CODIS database only once a week, so there would be plenty of time to crunch the numbers. And it's easy to protect offenders' privacy rights: You just separate the identifying information from the DNA profiles. Besides, if privacy were the overriding concern, the FBI wouldn't have allowed Troyer to project the photos of her nine-locus matches on the screen at a conference. (The FBI did not respond to a request for comment.)

Database guardians aren't above using a bit of muscle, either. After the release of its search results, the Arizona DPS got a cease-and-desist letter from the FBI, along with a warning that its conduct was "under review." (Troyer didn't return phone calls for this story.) In 2006, when defense lawyers in Illinois subpoenaed the 903 DNA matches that had turned up in their database, the FBI's CODIS chief, Thomas Callaghan, advised the state's crime lab administrators on how to fight it. As for Barlow, when she attempted to crack open the California database during a hearing on a case, the prosecution

warned that the FBI could yank the state's access to CODIS if it allowed any information into the defense's hands. "If the FBI pulled our authorization," the state's database administrator testified at a hearing, "it is just like if Microsoft…said we can't use Word anymore. We are shut down."

Why the resistance? To some extent, it's about the fundamental conflict between the law, which concentrates on establishing precedent and is loath to revisit those decisions, and science, which is willing to reevaluate even its most basic tenets when new evidence comes to light. "Science likes to open up closed questions," says Murphy, the UC Berkeley law professor. "Law likes to resolve." Another factor is the pure institutional arrogance of an agency unused to being challenged. As William C. Thompson, the UC Irvine scientist and lawyer who helped uncover evidence of falsified DNA testing at the now infamous Houston crime lab, puts it, "It's not about science or ethics. It's about authority and power. You know, 'It's our toy and you can't play with it.'"

The government may also be putting up a smokescreen. Some experts suspect that the FBI just doesn't want anyone to discover the plain old errors that they believe pervade the databases (such as analysts entering the wrong information) and that they have been trying to investigate for a decade. Dan Krane, a molecular biologist at Wright State University and CEO of an independent forensics lab that reviews DNA evidence primarily for defense attorneys, thinks the error rate—on the order of one in 10,000, he says—ultimately might be a far larger problem than the underestimation of matches that the Arizona data suggests.

One thing is sure: Though the underestimation of coincidental matches has gone largely unreported, except for a few recent *Los Angeles Times* articles, questions are likely to keep coming. As Marc Taylor, a former criminalist for the Los Angeles medical examiner, who now runs an independent crime lab in Ventura, puts it, "The bottom line is, we need to have some statisticians go in and find out what the hell is going on."

On the morning of December 22, 1972, a young nurse named Diana Sylvester was murdered in her apartment on Sixth Avenue near the UCSF campus. She had just returned from an overnight shift at the hospital and was probably thinking about getting some sleep. A little after 8 a.m., someone got into her apartment; there were no signs of forced entry, so either he talked his way in or she knew him. The killer forced Sylvester to take off her clothes and fellate him. Then, when he heard the landlady outside the apartment—she had come to see what all the noise was about—he murdered Sylvester, strangling her and stabbing her twice in the heart. When he saw the landlady at the front door (it was wide open), he snarled, "Go away, we're making love," and slammed the door.

The police had a suspect within days of the murder, and it wasn't Puckett. Instead, it was a Manson-esque

The defense is not allowed to mention that Puckett was identified through a cold-hit search. That means the jury will never hear that the bible of the forensic world says there may be a one in three chance Puckett's match was coincidental.

street artist named Robert Baker, who lived in a trash-filled Volkswagen van near Fisherman's Wharf. He had staged a violent breakout from an asylum the month before Sylvester's murder and raped a woman in her home less than a quarter of a mile from Sylvester's apartment. After climbing through her window, he blindfolded and gagged her, declaring, "I can rape you now or after you're dead." According to police records, Baker also stalked a young girl and her nanny on Sylvester's block. When the police finally picked him up in January 1973, just a few weeks after Sylvester's murder, Baker had small cuts on his fingers and face. In his van, they found mail stolen from Inner Sunset mailboxes as well as a parking ticket with drops of blood on it. The blood type matched Sylvester's, and Baker became the main suspect.

Everything goes dark after this. Baker appears to have been put in a police lineup, but there's no record of whether Sylvester's landlady ever came in to have a look. It's a moot point, anyway, since both Baker and the landlady are now dead. In addition, after more than 30 years in police department hands, the parking ticket went missing from the evidence room a few weeks before Puckett's preliminary hearings began.

While the case sat cold, Puckett was living in the Bay Area, doing odd jobs—carpet binder, nursing home administrator—and bouncing from address to address, an itinerant and troubled man. He has done more than his share of bad things in life: A string of sex crimes he committed in 1977 is what landed him in the state's criminal-offender database. On three separate occasions, posing as a cop and flashing a fake badge, he kidnapped women in San Francisco, forced them to drive to an isolated, woody area in Marin, and either raped them or forced them to perform fellatio on him. He got out of prison in 1985 and, besides an arrest for misdemeanor assault in 1988 (he wasn't convicted), has not been charged with any crimes since then.

But in 2004, the SFPD crime lab, as part of a nationwide push to reopen cold cases, dug into its files, pulled out the Sylvester case, and analyzed the DNA in the perpetrator's sperm, running it through the state's criminal offender database. Because the sample was old and had been moldering away in the basement of the medical examiner's office, analysts were able to read only five and a half locations conclusively—but they all appeared to match with Puckett. That's a far cry from 13, but the fact that Puckett had already committed sex offenses in the Bay Area gave the match more weight. Two years after the case was reopened, investigators found Puckett living with his wife in a trailer park in Stockton and sent him back to jail to await trial. He was 72 years old.

Cold-hit cases carry their own set of DNA controversies. In traditional investigations, a tip leads police to a suspect, and only then do they compare his DNA with that of the crime-scene sample. With a cold hit, a database trawl identifies someone who wasn't a suspect until his name popped up on the computer screen. The database search, in other words, *is* the tip. This scenario

Anatomy of a DNA match

WHY FINDING A CRIMINAL THROUGH DNA TESTING IS A MUCH DICIER PROCESS THAN YOU'D THINK.

Humans are about 99.9 percent alike at the cellular level—but scientists have found that predictable variations at certain locations, or loci, in our DNA distinguish us from one another.

These loci are found on the "rungs" of the DNA molecule's "ladder," above.

At each locus, there are two spots with measurable genetic material, called alleles, that experts compare from person to person or to crime-scene DNA to establish matches.

In 1997, FBI scientists decided on a predetermined set of 13 loci that is enough to indicate identity; most experts agree with that standard.

It's generally believed that only identical twins match at 13, and that the chances of a coincidental 13-locus match—meaning it's all a terrible mistake and the defendant is innocent—is, on average, one in a trillion.

The real difficulty comes when DNA evidence from a crime scene matches a suspect's DNA at fewer than 13 loci. When the DNA from the crime scene is old and degraded, for example, analysts are often unable to get reliable results for all 13 loci. They may be able to establish a match at only 10 loci, for example, or even 6. The remainder just can't be read.

When that happens, the odds that the match is coincidental rise accordingly. According to the rarity tables prosecutors use, the chance that a 10-locus match is coincidental might be one in 10 billion, depending on ethnicity; for a six-locus match, it might be as low as one in a couple of million.

While these still sound like long odds that the match is false, new research suggests that the FBI numbers may vastly underestimate false matches, particularly in cold-hit cases—those in which the suspect is identified through a database search, rather than through traditional police work. –C.S.

presents a statistical koan of sorts: What does a match mean when it's both your lead and your confirmation?

The government argues that the rarity should be calculated like that in most other cases: by using the RMP. This might sound sensible—a match is a match, right?—but many scientists insist that a cold hit requires a different calculation. As William C. Thompson, the UC Irvine scientist and lawyer, puts it, "To the jury, the DNA seems like a confirmation of guilt, when in fact it's the sum and substance of the evidence. It's a bit of a house of cards."

By way of explanation, Thompson says to think of a lottery. If you buy just one ticket, your chances of winning are infinitesimal. If you buy a lot of tickets, your chances are far greater. This concept, in effect, is what a cold-hit database search entails. By searching a database filled with hundreds of thousands (or maybe millions) of profiles, the government has bought itself a ton of

lottery tickets. And the greater the number of tickets, the greater the chance of fingering the guilty—but also the innocent—person. The RMP doesn't take this risk into account. "I'd sure hate to be in that database," Thompson says with a worried laugh.

There have been attempts to address this problem. In 1996, the FBI convened a group of forensics experts to study some of the field's most contentious issues. To correct for the possibility of a coincidental database match, the group's report (which prosecutors and crime-lab analysts alike refer to as "the bible") recommends that the RMP be multiplied by the size of the database searched, a conclusion that a great many (but not all) independent scientists agree with. That way, the reasoning goes, you're properly accounting for all of those lottery tickets you've bought. For a 13-locus match, this isn't such a big deal; if the database contains a million profiles, say, that one in a trillion might simply lose six zeros.

In Puckett's case, though, such a revision would have a major impact. Take the prosecution's number—one in 1.1 million—and multiply it by the size of California's database (roughly 300,000 profiles) at the time of the hit. Your new number is one in three—meaning that if you were relying on statistics alone and no other evidence tying Puckett to the case, there is a one in three chance that his match was a mere numerical coincidence. As Thompson explains, "In this case, the government bought itself 300,000 lottery tickets."

While it has embraced most of the report's conclusions, the FBI has ignored these cold-hit recommendations. As some of the agency's chief researchers argue in a paper often cited by prosecutors, the bible's recommendation was "not intended to supersede the random match probability estimate." Many judges, meanwhile, are either unaware of or indifferent to the current controversy.

Barlow thinks the Puckett case is the perfect platform for addressing both the Arizona evidence and the cold-hit controversy, but she knows it won't be easy to get either into trial. Judges don't overturn their colleagues' rulings lightly, and in both cases, she's up against precedent. California courts have repeatedly upheld the validity of the RMP, which the Arizona data challenges directly. And in relation to a key 1976 murder case in Sacramento, the lower courts ruled that the suspect's identification through a database search had no bearing on the rarity of his DNA match.

But the case is hardly open-and-shut for the prosecution, either, and I ask Barlow why she thinks they're going for it anyway. She scrunches up her nose, considering for a moment. "There's such a desire with these cold-hit cases to go back and find people and punish them, such a desire for finality," she says, then pauses. "They have a young woman who was murdered, and it was brutal and scary, and they have a family that wants justice." Another pause, then: "And they think my client is a bad man."

Much of the DNA testimony is lost in the static. It makes me think of something another attorney once told me about trying these cases: "You can make all the arguments you want, but at the end of the day, what the jury's gonna hear is match."

The case will take place in Department 21, a high-security courtroom sometimes used for gang trials that is outfitted with a thick plexiglass screen separating the bench from the gallery. The judge, a phlegmatic former prosecutor named Jerome Benson, has a reputation for running late, as he is today at this pretrial hearing.

To Barlow's chagrin, the judge has already narrowed the defense's options by barring any mention of Robert Baker, the escaped mental patient and street artist. The judge has ruled that evidence of alternate suspects can't just come from a list of names in the police file. The defense could have used direct testimony from actual human beings, but in a 35-year-old case, everyone besides the defendant is dead. It will be DNA or nothing, then, Barlow tells me.

That's about when Puckett enters the courtroom, pushing himself in a prison-issue wheelchair. A pudgy, pasty man wearing big glasses and orange jail sweats, he blinks under the overhead fluorescent lights, a frightened animal flushed out of its burrow. His feet are enormous due to poor circulation, and he underwent serious heart surgery shortly before his arrest in 2006. He has spent the last year and a half awaiting trial in the county jail's medical wing.

The battle today is over the Arizona data. Judge Benson is no DNA expert, and he knows little about what happened in Arizona or its implications for this case. Barlow will have to convince him if she wants to tell the jury about this crucial wrinkle in the DNA fabric. The sparring begins almost immediately. "This is not a case of a 13-locus match or even a nine-locus match," Barlow reminds Benson. "It is, to be charitable to the prosecution, a six-locus match." At that level, she says, the chance of its being coincidental is unacceptably high.

The prosecutor, David Merin, a boyish-looking Lowell High alumnus who buzzes with nervous energy, isn't buying it. He thinks that the Arizona evidence shouldn't be allowed into the trial because it's "half-baked"—he's skeptical of drawing conclusions based on summaries, rather than full genetic profiles, and he has some problems with the way Troyer ran her numbers—and "would be misleading and confusing to a jury."

Barlow stops short for a moment, as if rendered speechless by the audacity of the idea. "Frankly, to sit here and say that it would be too confusing for the jury is insulting," she says, with heat in her voice. "If we can't present this evidence," she says, "then the case is gone."

Judge Benson is quiet for what seems like days, scrutinizing the reams of papers on his stand. The courtroom is completely silent. Finally, he says, "I'm willing to be educated further."

The actual trial begins in January. Puckett wears a newly pressed oxford shirt and tie and studiously avoids eye contact with the jurors seated 20 feet to his right. Donna Gaylord, one of Diana Sylvester's sisters, appears in court today, having flown out from her home in Maine. She will be here every day, sitting vigil for her sister. ▶

These early days are taken up mostly with establishing the sad, bare facts of the case, the details that no one disputes. Creased, decades-old paper bags full of evidence are wheeled in on carts. They hold the clothing Sylvester was wearing when she died: a white nurse's one-piece uniform, a pink knit hat, a rain parka with her name written in marker below the tag.

There are also the photos. First, a pretty 22-year-old with dirty-blond hair and a wide, guileless smile. Then, pictures from the crime scene: a pale body splayed out on the carpet in front of the Christmas tree, clothes in a pile at her feet. The mood in the courtroom is uncomfortably intimate, weighted with misery.

We get to know the attorneys during these early days, too. Kwixuan Maloof, a barrel-chested, seven-year veteran of the public defender's office, is Puckett's lead attorney. He is teasing and funny, a showman who frequently makes the jurors laugh. Assistant District Attorney Merin, meanwhile, comes across as earnest and likable and is able to call on deep reserves of self-righteous anger at a moment's notice—a prosecutor's stock-in-trade. Barlow, the most cerebral of the attorneys, nonetheless wears her heart on her sleeve at all times—and it's about to get broken, since almost nothing has gone her way since the pretrial hearing.

In the weeks since then, Judge Benson has ruled against the defense again and again, essentially agreeing with the prosecution that the Arizona data would just muddy the waters. Worse, he has also barred the defense from mentioning that Puckett was identified through a cold-hit search, so the jury won't hear that the bible of the forensic world says there may be a one in three chance that Puckett's match was coincidental.

Barlow, though deeply disappointed, is not entirely surprised by the rulings. She says that while the judge appeared open to her arguments at first, he seemed to cool to them after studying Puckett's rap sheet. It's not easy, though, to keep a basic fact like a cold hit out of the trial, and hints emerge from time to time in the testimony. An investigator, for instance, refers in passing to Puckett's prosecution as a "cold case." Later, when the jury isn't present, Barlow protests that the exclusion of this evidence makes the prosecution's case seem stronger than it really is. The judge disagrees.

Inevitably, the jurors themselves begin asking questions. One day, an alternate juror, a young Mission-District type in glasses and trendy flats, submits a handwritten note that asks, "What information led police to the suspect?" Once the jury is out of earshot, Barlow makes her case again. "It's the elephant in the room," she argues. "It sort of infects the whole trial with this aura of reliability about the way he was identified."

The judge, though, won't hear of it. It doesn't matter, he says, asking the bailiff to bring the alternate back into the courtroom. "There is no evidence on this issue," he tells her. "I'm instructing you not to guess." Also, he adds, don't tell anybody we had this conversation.

At this point, Barlow is reduced to fighting with her hands tied behind her back. We take the elevator down after court, a silent and tense ride. Out on the street, she is lost in thought. "This whole thing is Kafka-esque," she eventually says, then walks off to her office. There is more work to do.

The thing about circumstantial evidence, which is all the jury has to go on apart from the DNA, is that it can be interpreted in many ways. One day, the jury is shown a videotape of Puckett's interview with Joe Toomey, the lead homicide inspector on the case, an old-school cop who was just a rookie when Diana Sylvester was murdered. The two are sitting across from each other in a tiny interrogation room. Like a predator so certain of the kill that he doesn't have to rush, Toomey leans in and says, almost gently, "We have a DNA match, and it comes back to you." Puckett's reply: "I…I…don't remember this at all."

So, is that a murderer's half-assed denial? Or the genuine protestation of a scared old man? It's like that all the way down the line: Puckett either matches the eyewitness description or doesn't. (Was he "medium-build with curly hair," as the description puts it, or "heavyset and balding," as photos from that time show him?)

His familiarity with the UCSF campus is either incriminating or not incriminating. (I happen to know the same shortcut at UCSF that Puckett knows.)

The fact that he had no regular job at the time of the killing is either suspicious or not. (Do murderers take days off or call in sick?)

Take your pick.

By any standard, however, there's no getting around the fact that Puckett's prior offenses look bad, and it doesn't matter how many times the defense notes that he has stayed out of trouble since then. One particularly chilling detail: He told a number of his victims, before he raped them, that he wanted to "make love." This statement, at least in prosecutor Merin's eyes, is uncannily similar to what Sylvester's killer said—"Go away, we're making love"—as he chased away her landlady, the only one who actually saw him, before slamming the door in her face. The flip side, of course, is that in 1972, everybody under the age of 50 talked like that.

Given all this uncertainty, and Judge Benson's exclusion of the defense's most persuasive arguments, the trial ends up hinging on an expert discussion of DNA esoterica, on aspects of DNA analysis related only vaguely to those Barlow brought up in the pretrial hearings. So little do the daily goings-on reflect the underlying issue of how accurate our DNA-match estimates are, it strikes me, that much of the testimony seems like an exercise in cognitive dissonance.

We begin our descent into deep, dark waters when Bonnie Cheng, the SFPD criminalist who compared Puckett's DNA profile with the crime-scene evidence, takes the stand. A handsome woman with a stylish gray suit and the sleek, silky hair of an otter, she wouldn't look out of place on *CSI*—an observation, I'd bet, that

> Scott Kauffman, Barlow's husband and also a defense attorney, has come out this morning to see his wife in court. A man with a keen sense of gallows humor, he laughs and says, "She got sandbagged."

hasn't escaped any of the attorneys. Testifying for the prosecution, she gives us our first glimpse of the electropherogram, a computer printout that illustrates the different genetic markers that characterize a DNA profile. The little mountain peaks that dance across the page indicate how much DNA is present at each locus. She also informs us that the crime-scene DNA evidence, because it contains genetic material from both the victim and, presumably, the perpetrator, is known as a mixed sample. Still, as Cheng tells it, her analysis was a straightforward process: She had merely to separate the suspect's DNA from Sylvester's, total up the peaks she saw on the printout, and plug the results into a formula (a modified version of the RMP) that yielded her a one in 1.1 million statistical calculation.

Trouble is, there's almost nothing simple about any of it. Mixed samples are another flashpoint in the DNA wars. It can be exceedingly difficult to separate one person's DNA from another's, especially in a degraded sample like this, and there is no universally accepted way to interpret the resulting profile. As the eminent British researcher Peter Gill told a conference of his fellow forensic scientists in 2005, "If you show 10 colleagues a mixture, you will probably end up with 10 different answers." Even Cheng's supervisor, a combative man named Matt Gabriel, reluctantly admits on the stand that there is no agreed-on protocol for handling mixed samples.

To complicate things further, Puckett's DNA sample is so degraded that there's precious little genetic material left to work with. It's certainly possible to include Puckett in this analysis, as Cheng does, but under questioning from Barlow, Cheng admits that on some of the loci, the notations she saw could have come from Sylvester instead of Puckett. Moreover, the crime lab used up so much of the sample in its analysis that the defense couldn't do its own testing—a fact that Barlow makes a point of mentioning to the jury.

Later, though, in a move that clearly takes Barlow by surprise, Cheng also testifies that Puckett's DNA might match that of the crime-scene sample at eight loci, rather than five and a half. Even though her results for these extra loci fall below the lab's interpretational standards, she tells the court that the extra loci on the crime-scene sample are nevertheless consistent with those on the Puckett sample. In her pretrial testimony last year, Cheng said she wouldn't use extra, "inconclusive" loci to identify someone, but now, for all intents and purposes, that's exactly what she's doing.

Barlow is livid. A through-the-looking-glass exchange ensues over the meaning of *inconclusive*. Reading Cheng's pretrial testimony back to her, Barlow asks, "Would you agree that the meaning of the word *inconclusive* is that no conclusions can be drawn?"

"Yes," Cheng answers, a pinched look on her face.

"And the reason why you don't rely on it," Barlow continues, "is because your own protocols say you can't?"

"That's correct," Cheng says.

The FBI claims that providing DNA data to outsiders would compromise criminals' privacy rights, and be so time-consuming that the business of crime-fighting would grind to a halt. Both arguments are bunk.

"So you would never say that any of those [inconclusive] peaks include Mr. Puckett or identify him, correct?"

"I didn't."

This is true. She didn't, because the crime lab's definition of *inconclusive* proves every bit as tortured as Bill Clinton's parsing of the word *is*. As far as the crime lab is concerned, we learn, *inconclusive* means only that the lab can't officially report those results or use them in its rarity calculations. It can, however, unofficially confirm that they match up with a suspect, and this unofficial confirmation can be allowed in court.

Barlow and her experts strive mightily to hammer home the essential ambiguity of it all. Marc Taylor, the Ventura crime-lab owner, explains to the jury the danger of relying on those extra two and a half loci. Mueller, the Irvine researcher who crunched the Arizona numbers, hits similar notes, ridiculing the crime lab's methods and, when the jury isn't present, citing the "near universal rejection" of its statistical calculations for cold-hit cases. In front of the jury, however, he can't say a word about either Arizona or cold hits.

Most of this testimony is lost in the static, anyway; every point is refuted diligently by Merin, in a lawyer's version of "he said, she said." The process makes me think of something another attorney, Anthony Monaghan, an assistant public defender in Charlotte, North Carolina, told me about trying DNA cases. "You can make all the arguments you want," he says, "but at the end of the day, what the jury's gonna hear is *match*."

For his expert rebuttal witness, Merin brings in Dr. Ranajit Chakraborty, the director of the University of Cincinnati's Center for Genome Information. Chakraborty, a small man with glasses and a nearly impenetrable accent, is what passes for a rock star in forensic circles. He is also the very definition of a government scientist—his work, he explains with pride, was cited "over 25 times" by the FBI-convened DNA report in 1996, and he has been a bureau consultant for close to 20 years. He got his bachelor's and master's degree at a school in Kolkata, India, "considered the premier worldwide institution of training and research in statistics," he says.

As one of the creators of the current DNA-testing regime, Chakraborty is intimately familiar with the genetic markers we've been hearing about for weeks. As such, he talks about them with a weirdly paternal fondness that verges on the unscientific. "These are my babies," he says on the stand, outlining an almost mystical connection to the peaks on the printout.

With that, he begins to attack each of the defense's arguments, explaining that while the evidence may look ambiguous to some people, he can see to the very heart of the printout—and what he sees is guilt. Inconclusive data, low-level data, mixed samples—no matter. Using Puckett's DNA profile as a guide, Chakraborty prunes away the irregularities and uncertainties to hang him. Barlow tangles with him over these assumptions, but Chakraborty barely bends, and the proceedings quickly devolve into jargon-filled hostilities.

During one particularly testy exchange, I catch one of the jurors laughing. She looks like she feels sorry for Barlow.

It's a hell of a show, and Barlow—who wasn't informed of the breadth of what Chakraborty would testify to today—is caught flat-footed. With the jury in recess, she protests to the judge. This man, she says, "is willing to reach as far as he can go to serve Mr. Merin's purpose." Merin maintains that his witness is merely rebutting Barlow's expert-witness testimony; Judge Benson sides with the prosecution.

I look back at Barlow's husband, Scott Kauffman, who is also a defense lawyer and has come out this morning to see his wife in court. A man with a keen sense of gallows humor, Kauffman laughs and says, in an I've-been-there way, "She got sandbagged."

The arguments end on Valentine's Day, and the jury files through a door on the side of the courtroom to begin its deliberations. Barlow and Maloof push through the old wooden doors and into the hallway. They look drained. "Well, it's over," says Barlow with a shrug.

But now comes the hardest part: the waiting. The struggles of the past few years, the pitched battles with one judge after another, are clearly wearing her down. I ask her how she's feeling about the trial.

"I have mixed feelings," she says, clearly trying to put a positive spin on it. "I feel like we did as good a job as we could under the circumstances." She trails off; suddenly, being positive seems to take too much effort. "But we're fighting the weight of the whole system here."

For a moment, she seems close to tears. Right now, it's possible to see just how much these reversals have taken out of her. "This case was the epitome of a miscarriage of justice," she continues, her voice cracking a little. "If he's convicted, how can I participate in a system that's so broken?" Not for the first time, she wonders if she might be better off doing something else with her life.

I run into Barlow in the hall a few days later. The jury has been out for three days and counting. The length of the deliberations seems to have buoyed her hopes. "I think the verdict will come in today," she says, sounding cautiously optimistic. She's hoping for at least a hung jury. After all, from a purely legalistic standpoint, defenders aren't required to prove their clients innocent; they just need to create reasonable doubt. As Barlow told the jury in her closing statement, reasonable doubt is "an abiding conviction, such that a year from now…you won't wake up in the middle of the night and say, 'Oh my god. Did I do the right thing? Was that DNA wrong?'"

The verdict comes in at about 3 that afternoon. I've never seen the gallery so crowded: There are spectators from both the DA's and the PD's offices, assorted paralegals and interns, reporters and detectives. Puckett wheels himself into the courtroom, taking his customary place at the defense table. He looks up briefly, surveying the room—his eyes betray nothing, though, as Maloof tells me later, he was so scared that he couldn't tie his

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own tie—then bows his head. Barlow gives his shoulder a couple of small, warm pats. Puckett clasps his hands in prayer, bows his head deeper.

One by one, the jurors file into the courtroom. To get to the jury box, they must walk past Puckett. No one looks his way, and I wonder if the old saying—that the jury won't look at a man it has pronounced guilty—actually means anything. The gallery goes silent as the foreman hands a note to the bailiff. The wait is excruciating. Then: Guilty of murder in the first degree.

There is an explosion of emotion from the seats behind me, from Donna Gaylord, Sylvester's sister. She is red-faced, crying. Relief and pain in equal measure.

Over at the defense table, Puckett's head is still bowed. Barlow and Maloof are stone-faced. As the judge ratifies the verdict, Barlow stares off into space. The judge is thanking the jurors for their work, complimenting them on their dedication to working through a thorny and complicated case. "You may now consider yourselves to be experts…on DNA evidence," he tells them. Many of them are beaming.

Out in the hall, the jurors answer questions from the defense lawyers. There are a million conversations at once, and few of the jurors feel like talking to me, but I get the gist of their deliberations.

Most of them found the circumstantial evidence persuasive, especially when combined with Puckett's criminal history, even if some of the details of the crimes differed. But the DNA mattered very much to most of them, too. They didn't buy the defense's arguments about the essential sketchiness of degraded, mixed DNA samples. Of course, they didn't hear anything about the Arizona database or the controversy over cold-hit database matches.

Maloof asks a knot of jurors how they figured Puckett became a suspect. Did they think it was a cold hit?

"We asked, and were told it was irrelevant," says one.

"Yes, why didn't you present any information on that?" another juror asks Maloof.

"Because we weren't allowed to," Maloof replies morosely. It feels like an important exchange, but only a few people hear it. (In fact, a few months later, in an appeal of the 1976 Sacramento case, the California Supreme Court ruled that the revised rarity estimates in cold-hit prosecutions recommended years ago by "the bible" *are* admissable in some cases, a decision certain to be central to Puckett's appeal.)

Joe DeLuca, a thoughtful, 49-year-old martial arts instructor, is the only juror willing to talk at length. Like the others, he was impressed by Bonnie Cheng's testimony, and he lauds the work of the SFPD crime lab. He says he didn't believe there was enough evidence to convict Puckett without the DNA, though a few other jurors thought otherwise. When asked if a different statistic—say, a one-in-three chance that it was a coincidental match—might have made a difference in his judgment, he says, "Of course it would. That would have changed everything." ■