Current Issues in Forensic DNA Applications

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March 17, 2015

Forensic DNA Highlights

What is CODIS?

- Match DNA sample to suspect DNA at variable locations on the genome (loci).
- CODIS: Database containing STR profiles at 13 different loci, submitted by law enforcement
- Access and sample contribution is restricted to preserve database integrity and privacy

Balancing crime-solving w/ privacy and the Fourth Amendment: Maryland v. King

- States are gradually expanding the number of crimes for which DNA is collected
- More states are passing laws to collect DNA from arrestees even before conviction
- *Maryland v. King* (2012) ruled that arrestee DNA collection is constitutional
- Recent cases are further exploring what limitations apply to arrestee DNA collection

Protection of civil liberties:

- Familial searches: should police be able to search the national database for <u>relatives</u> of a suspect? Currently legal in four states, illegal in one, not yet addressed in the rest
- Can law enforcement analyze "discarded" DNA without the individual's knowledge? A recent refusal by SCOTUS to hear a case suggests the government's answer is "yes."
- Forensic DNA phenotyping: it is possible to "sketch" a suspect based on DNA collected from a crime scene when no eyewitnesses were present. Does this violate privacy or promote discrimination? And does the science yield reliable sketches? The jury is still out.
- How do these policies exacerbate racism in the criminal justice system? African Americans, for example, are four times as likely as Caucasians to be matched in a familial search.

Should we have an all-inclusive national DNA database?

- Would make crime solving easier and would eliminate racial bias in familial searches
- Would also be expensive, time consuming, and raises serious privacy concerns

DNA Backlog

- Approximately 90,000 cases and 113,000 convicted offender or arrestee profiles were backlogged (unprocessed after at least 30 days) at the end of 2011.
- Growing demand for DNA analysis outpaces recent increases in crime lab productivity
- Many rape kits are backlogged for years, which allows the rapists to continue committing crimes

Use of DNA for exoneration

- 1988 exoneration of Gary Dotson demonstrated use of DNA to reverse wrongful convictions
- 1992: Innocence Project founded to promote use of DNA for exoneration
- Several legal and logistical obstacles persist, including refusal to allow post-conviction access

The Rapid DNA Act

- Dec 2014 bill to integrate rapid DNA genotyping technologies into law enforcement
- Would allow law enforcement to compare crime scene DNA to CODIS in two hours
- Concerns include risk of expanding access to CODIS, overzealous collection

How should we run forensic science?

- Studies have revealed significant error rates in forensic DNA analysis
- Disagreement over validity of techniques causes confusion in legal system
- High-profile cases of corruption and misuse of DNA evidence reveal need for increased vigilance

White Paper: Current Issues in Forensic DNA Applications

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Introduction

Since shortly after its integration into law enforcement and legal proceedings in 1987, DNA evidence has been regarded as the gold standard of forensic evidence. DNA analyses are among the easiest forensic techniques to apply consistently and they yield quantifiable confidence levels. In a short time, a large database of DNA samples obtained from arrestees, as well as infrastructure to search against this database, was established at the federal level. On the other hand, the use of forensic DNA has aroused concerns about civil liberties at every stage of its application. The appropriate use of forensic DNA has always required a balance between preserving personal privacy and improving crime solving. But while law enforcement is likely to catch more bad guys with the inclusion of more DNA samples in its databases, civil libertarians wonder about the unintended consequences of such expansion.

Recently, as the technology has been enthusiastically embraced by law enforcement nationwide, the demand for forensic DNA services has led to a backlog of samples, including unprocessed rape kits. Overcoming this backlog will be critical for law enforcement to realize the full benefits of forensic DNA.

Other pressing problems have emerged regarding the administration of forensic DNA at the national level. Laxity regarding the validity of analyses used and even instances of corruption and deceit have arisen. Measures to improve the accuracy and utility of DNA collection and sample matching are being considered by the FBI as well as Congress. Here we offer an analysis of the issues facing forensic use of DNA, current efforts to grapple with them, and possible approaches to ensuring consistent, effective and just application of this powerful technology.

Background: What is CODIS?

The use of forensic DNA relies on the observable differences between the unique DNA sequences of individuals [1]. On average two unrelated humans differ at one in1300 DNA sites among the six billion letters ("nucleotides" denoted by A, C, T and G) of DNA found in a human (the genome). By comparing the sequences at particular sites in the human genome, it is possible to estimate the likelihood that both samples originated from the same donor. This allows investigators to determine with a high degree of certainty whether DNA left at a crime scene belongs to a suspect. The parts of the genome that are examined in current forensic techniques are called Short Tandem Repeats (STR) [2]. These regions display great variation between individuals, and are not associated with diseases or other traits deemed inappropriate by authorities to avoid disclosure of private medical information [3]. These sites have a variable number of repetitions of a particular set of nucleotides. Analysts use a technique known as Polymerase Chain Reaction (PCR) to amplify the DNA from vanishingly small quantities found at crime scenes and more easily examine the number of repeats.

The FBI currently uses 13 different STRs in the genome to provide greater confidence in the results of a comparison [4]. These data are also easily stored as an individual DNA profile. The FBI created the Combined DNA Index System (CODIS) in the DNA Identification Act of 1994 to provide a central repository for DNA profiles generated by law enforcement at the national and state levels [2]. Law enforcement can attempt to match a profile obtained from the crime scene with the database. If a match is found, law enforcement has probable cause to pursue a biological sample from the donor of the database entry, and conduct a second DNA analysis [2]. This evidence can then be presented in court.

To maintain quality standards for CODIS the FBI has authorized the nonprofit boards American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB) and Forensic Quality Services (ANSI-ASQ National Accreditation Board FQS) to accredit labs that contribute to the database. All states that participate in the database also must agree to stipulations in the DNA Identification Act; these include restricting access to the database to individuals approved by the FBI, ensuring DNA data confidentiality, and limiting access to uses directly related to law enforcement identification [4]. There are also limitations on disclosure of database information: only verified law enforcement agency partners, judicial proceedings, and the defendant have access to complete profiles, while data cleared of personal information can be used for population statistics or quality control. According to FBI reports, as of January 2015, the CODIS index currently holds 11,592,430 offender profiles, 1,325,123 arrestee profiles and 607,173 other forensic profiles obtained from crime scenes [4]. In addition, as of January 2015 the database had been consulted in more than 261,000 investigations.

Who is included in CODIS?

How do we balance privacy with crime-solving? Maryland v. King and the aftermath

Recently, there has been a national trend toward collecting arrestee DNA not only for serious felonies such as rape and assault, but also for less serious felonies and even misdemeanors. In such cases, when a suspect is arrested, police departments take a DNA swab from the suspect’s cheek and compare the sample with the entire CODIS database to see if the suspect’s DNA matches crime scene evidence from any previous cold cases.

States with arrestee DNA collection laws. Image source: National Conference of State Legislatures

The DNA Fingerprint Act of 2005 mandated that all people arrested for federal felonies, sex crimes, or violent crimes provide a DNA sample upon arrest. However, states have the authority to set their own laws governing arrestee DNA collection for non-federal crimes. According to an NIJ report written in June 2012, 28 states had laws requiring DNA collection for crimes beyond the federally mandated list [5]. Of these states, 13 required DNA collection for all felonies, while the others required it for only a subset of "serious felonies." Only 11 of these states required proof of probable cause before collection. Eight states (Alabama, Arizona, Kansas, Louisiana, Minnesota, North Carolina, South Carolina, South Dakota) had a specific list of misdemeanors for which arrestee DNA collection was required; for example, North Carolina required submission of a DNA sample upon arrest for stalking, cyber-stalking, and any offense for which the arrestee would be required to register as a sex offender [6]. In the other states, arrestee DNA collection was still limited to felonies. In 13 states, if the individual was acquitted of the crime, the state would automatically expunge DNA evidence; in the other states, the individual would have to specifically request removal of evidence. Since the NIJ report was released, Nevada and Wisconsin have passed arrestee DNA collection laws, bringing the total number of states with such laws to 30. [5]

Some states are currently extending their lists of crimes for which arrestee DNA is collected [7]. A proposed Virginia law would collect arrestee DNA for 99 additional misdemeanors [8]. Supporters of this bill argue that expanded arrestee DNA collection could help to find dangerous criminals who have not yet been identified. For example, convicted Charlottesville serial rapist Nathan Washington would have been unable to rape seven victims had he submitted a DNA sample after his arrest for a misdemeanor in 1998 [8]. In New York, convictions for certain misdemeanors such as shoplifting require DNA collection, and this has led to 703 DNA matches for other crimes since 2012 (not all of these have resulted in convictions) [8]. The New York law, however, applies to convicted offenders, not people arrested on suspicion of an offense. The American Civil Liberties Union and others argue that arrestee DNA collection violates the Fourth Amendment right to privacy and freedom from unreasonable searches and seizures [9]. Much of the debate over collection of arrestee DNA boils down to a question of whether the societal benefit of solving serious crimes is enough to justify the intrusion upon the arrestee's privacy, and whether that intrusion should extend to arrests for lesser crimes.

The courts have struggled to strike a balance between the public utility of solving crimes with forensic DNA technologies and respect for the suspects' Fourth Amendment rights. In 2013, one such case, *Maryland v. King*, reached the Supreme Court. Alonzo King was arrested for assault in 2009. By virtue of the Maryland DNA Collection Act, the investigators took King's DNA sample upon arrest. Following King's conviction for assault, investigators entered his DNA into the national database and found a match to an old rape case. They subsequently charged King for first-degree rape and convicted him using this DNA evidence, sentencing him to life in prison. [10]

In *Maryland v. King*, the defense argued that the collection of King's DNA immediately upon arrest was unconstitutional under the Fourth Amendment. Since the primary purpose for this collection was to compare the DNA against other crime-scene and suspect samples for which there was no "individualized suspicion" against King, King's lawyers argued that the collection was equivalent to a warrantless search, and therefore unconstitutional. On the opposite side, the state of Maryland argued that DNA collection is only a small intrusion and a simple matter of identification. It reasoned that someone who has been arrested must expect a lower level of privacy than a normal citizen, and that DNA fingerprinting—like conventional fingerprinting—is important for expediting the criminal justice process. [10]

The Supreme Court ruled 5-4 in favor of Maryland, with Justice Kennedy writing for the majority. The majority opinion did not concede, as the defense suggested, that DNA fingerprint collection represented a departure from previous police booking practices due to its frequent use in solving cold cases. The five justices emphasized that collection of a suspect's DNA is merely a means of identification, and that fully identifying a suspect may entail linking the suspect with other previously committed crimes. DNA fingerprinting, they argued, is no different in principle from traditional fingerprinting, but is more precise and more efficient. [11]

The other 4 justices, led by Justice Scalia, wrote a withering dissent. Their main point of criticism was that the decision allows police to search people who are not reasonably suspected of a crime, based on DNA evidence collected from a different, entirely unrelated crime. DNA fingerprinting of arrestees, they argued, is different in scope from other identification methods because it is not used primarily to solve the crime for which it is collected, but rather to solve other cold cases. Although the majority opinion acknowledged that DNA collection need only occur following arrests for "serious" crimes, Scalia's dissent expressed doubts that law enforcement officials would actually restrict themselves to collection for serious crimes. Furthermore, Scalia pointed out that enhanced crime solving alone is an insufficient argument in favor of expanded DNA fingerprinting, since many more cases would be solvable if the police completely ignored Fourth Amendment rights. [11]

Is DNA fingerprinting truly the 21st century version of traditional fingerprinting? One important distinction between DNA fingerprinting and traditional fingerprinting is that DNA samples, if not destroyed following entry into a database, can potentially provide a wealth of personal health-related information that is not revealed in a traditional fingerprint. As for the system of maintenance, the FBI's Integrated Automated Fingerprint Identification System (IAFIS) currently contains fingerprints for over 70 million individuals; fingerprints are added for arrests as well as background checks for some jobs. Automated fingerprint matching is available for solving cold cases, and the FBI gives an annual "Latent Hit of the Year" spotlighting an investigator who uses IAFIS to solve a cold case with no remaining leads [12]. In this regard, maintenance of DNA fingerprints within CODIS, as described previously, is quite similar to maintenance of traditional fingerprints. Of course, nationwide fingerprint searches in IAFIS have only become a real option recently due to technological improvements providing increased accuracy and efficiency, so it might be premature to gauge the uptick in the use of IAFIS.

Since the Supreme Court's ruling in *Maryland v. King*, debate over the specific limitations of arrestee DNA collection policies has continued unabated. In 2014, several major state-level cases explored similar scenarios to the one in *King*. In both *Haskell v. Harris* and *People v. Lowe*, the state of California ruled consistently with the Supreme Court that arrestee DNA collection does not violate the Fourth Amendment. Similarly, in *Raynor v. Maryland*, the court sided with SCOTUS's decision and even extended it to a case of surreptitious DNA collection (discussed further in the next section). However, in the California case *People v. Buza*, the court ruled that although arrestee DNA collection is acceptable under the US constitution by virtue of SCOTUS's ruling, the state constitution of California gives arrestees additional rights, protecting them from collection of their DNA without prior determination of probable cause in court [13].

The California Supreme Court has recently decided to review both *People v. Lowe* and *People v. Buza*. The court's ruling in these two cases will likely come down to a question of whether arrestee DNA collection is used primarily for identification, as decided in the *Lowe* ruling, or for investigation of unrelated cases, as decided in the *Buza* ruling [14]. The Vermont case *State v. Medina* reached a similar conclusion to that of *Buza*: arrestee DNA collection violates the Vermont state constitution. In summary, these cases suggest that DNA arrestee collection is legal under the national constitution, but at least for now, states still have their own power to restrict forensic use of arrestee DNA. [15]

Do current policies governing forensic DNA adequately protect our civil liberties?

As forensic DNA technologies improve, it is becoming increasingly easy to catch criminals using DNA. However, some argue that certain current or potential forensic uses of DNA jeopardize US citizens' privacy and presumption of innocence. Three such issues currently under discussion are familial searching in CODIS, surreptitious DNA collection, and use of DNA to identify externally visible characteristics. We will also discuss the implicit racial biases that arise from using some of these methods to track criminals.

Familial searching is the use of the CODIS database to identify people whose DNA partially matches that found at a crime scene. If an individual's DNA matches the crime scene evidence at 13 or more of the 16 STRs, but not all of them, this may indicate that the matched individual is a parent, child, or sibling of the perpetrator [16]. Thus, when investigators find a partial match in the CODIS database, they may consider the matched individual's immediate relatives as a new set of suspects. The most famous example of familial searching in the US is the case of California's "Grim Sleeper," a serial killer responsible for 10 or more murders in Los Angeles, spanning a period of 25 years. In this case, the police found a partial match between the crime scene evidence and the now-alleged murderer's son. They used this knowledge to track down their primary suspect, obtain his DNA, and verify that the profile was indeed a perfect match to the evidence found at the crime scene [17]. As of 2011, familial searching was legal in 4 states (California, Colorado, Texas, and Virginia), but only if all other leads have failed. Maryland and Washington, D.C. have explicitly outlawed the practice [16].

One objection to familial searching is that it makes suspects out of innocent people; opponents therefore claim that it violates the Fourth Amendment [16]. There are some concerns as to how far states might go to catch criminals. So far the states mentioned above have been cautious of privacy concerns, only using familial searching to test for immediate relatives in serious felony cases with no remaining leads [18]. But some worry that as familial searching becomes more commonplace, these states might gradually ease some of these restrictions. A more relaxed definition of what constitutes a "partial match," for example, might widen the circle of suspects from only first-degree relatives to second-degree relatives and beyond.

Implicit racial and ethnic biases exist in the use of familial searching. Minorities whose relatives are overrepresented in the database have a greater chance of detection through a familial search. According to a 2011 estimate, 17 percent of African Americans have familial matches in the

CODIS database, while only 4 percent of Caucasians have familial matches under the same search criteria [18].

Surreptitious collection of DNA from crime suspects is another issue that has aroused controversy. For example, in the Grim Sleeper case discussed above, undercover police officers obtained the suspect's DNA from a discarded pizza crust [17]. Similarly, in the case *Maryland v. Raynor* (2014), discussed briefly in the previous section, police harvested Raynor's DNA from his chair in the police station after he left the room, without his permission. Thus, the court's decision in *Maryland v. Raynor* to side with Maryland goes beyond the ruling of *Maryland v. King* by not only allowing collection of arrestee DNA, but also without the suspect's knowledge [19]. The ruling only allows analysis of the 13 STRs that do not reveal any health or trait information, but some fear that once the government holds a person's DNA, it will not limit its analyses to this set of core loci (a locus refers to a particular location in the genome). This decision has again drawn criticism from civil liberties advocates; the Electronic Frontier Foundation (EFF) filed an amicus brief on February 19, 2015, requesting that the Supreme Court hear this case [20]. On March 2, 2015, the court declined, meaning that involuntary, surreptitious collection and forensic analysis of DNA is constitutionally legal, state laws against it notwithstanding [21].

Among the cutting-edge applications of forensic DNA technology is the use of crime scene DNA to determine a perpetrator's externally visible characteristics (EVCs). Certain loci in DNA have known associations with eye color, skin color, hair color, and facial structure, meaning that investigators can use crime-scene DNA to construct a "best guess" image of the perpetrator's appearance. Such a strategy is useful when no other leads remain and there are no eyewitness accounts of the perpetrator. The first attempted forensic use of such evidence was for a South Carolina double homicide case: in January 2015, the police department released a sketch of the suspect generated entirely from the crime scene DNA, courtesy of the company Parabon Nanolabs. For each of the traits depicted, the sketch showed a range of confidence: for example, the suspect's hair color was judged to be anywhere within the spectrum of light brown to black, was definitely not red or blond, and had the highest likelihood (59.3%) of being a shade of dark brown [22].

Proponents of so-called forensic DNA phenotyping—that is, estimation of physical traits using DNA markers akin to a composite sketch—argue that a witness could have seen any of the "externally visible" characteristics shown in the image; therefore, generating and distributing this image of a suspect is no more a violation of privacy than having an artist sketch and distribute an eyewitness description of the suspect. Furthermore, they argue, a phenotypic sketch is more reliable than an eyewitness sketch, as an eyewitness's memory is often faulty [23]. Others argue that forensic phenotype sketches should be off-limits, at least for now, because the results are probabilistic and vague. They also worry that such techniques will lead to increased racial profiling within law enforcement agencies [24].

In summary, advances in forensic DNA technologies promise to provide more crime-solving power. At the same time, a number of questions arise about just how far law enforcement officials can go with these analyses before they become an excessive invasion of privacy or even a form of subtle discrimination.

Should we create an all-inclusive national DNA database?

Some forensic experts have suggested that the US government should expand the national CODIS database to include DNA from every US citizen. This would eliminate the racial imbalances in availability of DNA within the database. It would make it much easier to solve crimes and cold cases for which the perpetrator's DNA is not yet in CODIS [25]. It would also simplify the identification of bodies after a natural disaster, accident, or attack on the civilian population [26].

Implementation of such a database would be a challenge. An enormous backlog of unprocessed forensic DNA samples already exists, and mandating such a massive-scale DNA collection under the current infrastructure would worsen this situation, diverting resources away from actual crime-solving [25]. Another question would be how to obtain the DNA samples from citizens. This would be relatively simple if the government simply required individuals to submit their DNA when renewing a driver's license or passport, when undergoing a routine background check, or, for newborns, immediately at birth. In fact, the state of California already preserves blood spots from newborn screening tests for every individual, and it would relatively trivial to extract the DNA from all of these samples [27]. One more challenge in implementation would be the limited statistical power of the database to accurately identify a single perpetrator from within a database with hundreds of millions of samples: with just 13 core STR loci currently in use, one could find multiple unrelated members of the population with the same DNA profile [28]. For this reason, implementation of a national database would likely require expansion of the core CODIS STR loci, which we discuss in a subsequent section.

Opponents of an all-inclusive national database liken the idea to a DNA dragnet that implicates many innocent people as suspects with the hope of finding a single actual offender. Under the current CODIS system, it might be possible for an innocent person to be linked to a crime simply because he or she was present at the crime scene at a different time than when the crime actually occurred [25]. A national DNA database would exacerbate this problem. Furthermore, if the samples used to generate the database are not destroyed after extracting the STR information necessary for forensic comparisons, the possibility remains that the government might later extract further genetic information for purposes not related to crime-solving with probable cause. To avoid such complications, some have suggested destroying every person's DNA sample immediately after typing its CODIS loci. [26]

Use of DNA for exoneration

In cases where DNA evidence remains accessible after conviction, there is an opportunity to reverse wrongful convictions. In many past cases DNA evidence has been improperly interpreted, or entirely ignored, due to a lack of effective analytical tools and low awareness for the utility of this evidence. Furthermore, several factors have been linked to an increased likelihood of wrongful conviction. Racial minorities have historically been overrepresented among exonerated offenders [29]. Unreliable eyewitness testimony has been identified as the greatest cause of wrongful convictions [30]. Some forensic techniques, such as bite mark analysis, have also proved to be instrumental in leading to wrongful convictions. Lastly, false confessions have contributed to some cases of wrongful convictions. Oftentimes the wrongfully convicted individual was found to suffer from mental illness [31].

The case of Gary Dotson in 1979 was the first one in which a convict was exonerated on the basis of forensic DNA evidence [32]. The case was a proving ground for forensic DNA technologies that were cutting-edge at the time. The victim claimed that two strangers raped her in the back seat of a car. The victim also had cuts on her stomach, which she said were inflicted by a man writing words using cut glass. The victim cooperated with police to create a sketch of the perpetrator, with which the prosecution identified Dotson in a police sketchbook. The forensic analyst misinterpreted data from trace blood antigens in the bodily fluids left in the victim's underwear, vastly overestimating the probability that the donor was Dotson. On the basis of this and other evidence, Dotson was convicted in 1979 of kidnapping and rape. Some six years later, the victim recanted the testimony, stating that she had falsified the rape allegations to cover a sexual encounter with her boyfriend. Despite this, the judge refused to grant a retrial on the basis that the victim had since become mentally unstable. Later, Dotson's attorney turned to new DNA testing technologies that were unavailable during the trial. One of the analyses was successful despite sample degradation, and excluded Dotson as the donor, while indicating that the victim's boyfriend was a likely source. Ten years after the initial verdict, Dotson's conviction was overturned. The case validated the power of forensic DNA technologies to inform investigations, and to overcome uncertainties present in other forms of evidence.

As awareness of the power of DNA evidence to shed light on uncertain criminal investigations grew, an organized effort to apply these new techniques to wrongful convictions grew among forensic scientists and legal scholars. The Innocence Project was started in 1992 to use DNA evidence to exonerate wrongfully convicted individuals. To date, more than 300 wrongfully convicted individuals have been freed on the basis of DNA evidence [33].

Despite the promise of DNA-based exoneration to reverse injustices and improve the accuracy of criminal investigations, efforts to reverse wrongful convictions are often hampered by obstacles to access to DNA evidence. The procedural guidelines for providing DNA evidence for post-conviction testing vary from state to state. For instance, the state of New York lacks any statute regarding the preservation of biological samples, and the state's regulations regarding processing of biological samples do not meet criteria laid out by the National Institute of Standards and Technology [34]. Recent legislative action in Congress seeks to address this issue. H.B 1069, sponsored by Rep. Tina Orwall (D-IA) would require DNA evidence from violent or sex-related felonies to be preserved throughout the offender's sentence [35]. The alleged goals of the legislation are to standardize policies regarding preservation of DNA samples post-conviction across states, and to facilitate post-conviction appeals. The bill passed the house on a bipartisan vote in February, and has been referred to the Senate. Other obstacles to accessing DNA evidence posed by state laws include denying access when a guilty plea was made or requiring evidence that new DNA testing would reveal the true perpetrator [33]. In addition, petitioning for access to DNA evidence is often prolonged by procedural requirements and prosecutorial objections, as seen in the high-profile prosecution and eventual exoneration of Michael Morton. Involvement of the Innocence Project in this case eventually led to the discovery of prosecutorial misconduct [36]. Some scholars believe hiding such misconduct has led to district attorneys' reluctance to allow retesting of DNA evidence [36].

How can we reduce the forensic DNA backlog?

How much backlog exists, and is the situation improving?

For more than a decade, the number of new DNA samples requiring processing in crime labs has exceeded labs' capacity to handle these samples. This backlog is of obvious concern to law enforcement officials since unanalyzed samples cannot be used to close cases. Backlog includes both casework awaiting completion and profiles of arrested or convicted offenders waiting to be uploaded to CODIS. The NIJ did not adopt a formal standard for defining backlog until 2011; starting in 2011 the NIJ required all the labs it funded to report as backlogged all samples older than 30 days. The number of backlogged criminal cases increased from 83,603 to 91,323 during 2011. While the number of cases finished in 2011 (248,085) increased by 10 percent from the previous year, the number of new cases submitted also increased by 16.4 percent. At the start of 2011, there were 187,034 backlogged samples from arrested or convicted offenders waiting to be submitted to CODIS, but by the end of the year there were only 113,531 backlogged samples.

Although the number of samples submitted is high, the labs can process many of these samples each year: in 2011, forensic labs finished processing a total of 793,457 CODIS submissions. [37]

The federal government has worked to reduce this backlog for over a decade. In 2004, Congress passed the Debbie Smith Act to reduce forensic backlog. The law was named for Debbie Smith of Virginia, who was raped in her home in 1989. She submitted a rape kit immediately after, but law enforcement officials failed to process the kit until five years later, at which point Smith's attacker had already raped two other victims [38]. The primary purpose of the Debbie Smith Act was to appropriate money for expanding the CODIS database with new samples and for processing backlogged samples. Congress has renewed the Act twice, first in 2008 and most recently in 2014. The most recent bill appropriated an additional $968 million over 2015-2019 for the purpose of reducing backlog [39]. These monies are to subsidize opening more labs, hiring more personnel trained in forensic DNA analysis, and increasing the efficiency of operations.

The growth in availability of DNA analytical tools and their declining costs have caused a surge in demand for DNA analyses of crime scene evidence. The number of new convicted offender and arrestee samples decreased by 51% in 2011 compared with 2009, but since states are expanding their powers to collect and process DNA for more minor offenses, some question whether this downward trend in the number of convicted offender and arrestee profiles will continue [40]. Thus, the only ways to eliminate the DNA backlog are to further improve capacity and efficiency of labs so that they can process more samples than they receive, or to reduce the number of crime samples and arrested/convicted offender profiles submitted for processing.

The rape kit backlog is arguably the most alarming. Hundreds of thousands of rape kits have sat idle, in some cases for years, before state crime labs have tested them. Some law enforcement officials argue that this backlog is overstated since some of these untested kits are never needed in court as evidence. Advocacy groups respond that if a rape survivor went through the four- to six-hour process of submitting a rape kit, the survivor deserves to have that kit tested [41]. Regardless, it is safe to say that the number of "true" backlogged rape kits is large. We do not have a clear sense of the extent of this problem: in many cities it is still unclear how much backlog exists. The non-profit Joyful Heart Foundation's "End the Backlog" campaign reports, "We cannot know the true extent of the backlog because few state governments and no federal agencies require that police departments count or track the kits in their possession." Most of what we currently know about the rape kit backlog has been reported not by the crime labs themselves, but by news reporters and other outside investigators [41].

In 2013, the Sexual Assault Forensic Evidence Reporting (SAFER) Act gave states the power to conduct audits of rape kit backlogs [42]. Houston recently processed its backlog of 6600 rape kits, some of which were submitted decades ago. As a result, law enforcement officials have brought charges against 29 suspects; thus far six have been convicted [43]. Six of these 29 suspects also allegedly committed other crimes while their kits sat in the queue [44]. Houston's efforts mark a major step forward for processing the rape kit backlog, but a large backlog of untested rape kits remains elsewhere. For example, in Louisiana, over one third of the 1300 backlogged rape kits are over 5 years old [45]. The backlog problem is likely to persist so long as the state crime lab system lacks 1) resources and 2) transparency.

How can police departments work around the backlog? The Rapid DNA Act

The slow pace of processing of DNA samples through traditional routes has consequences for the effectiveness of law enforcement immediately after the occurrence of the crime. DNA data could assist law enforcement in the early stages of an investigation by excluding innocent suspects and allowing for more timely arrests of likely perpetrators. However, there is no existing workaround for law enforcement to more quickly go through the process of sample analysis and database queries meant to match DNA samples to donors. To address this need, a bill was introduced to Congress in December of 2014 by Rep. James Sensenbrenner Jr. (R-WI) to establish a system that would integrate rapid DNA analysis technologies with CODIS access at the law enforcement level [46].

The rapid DNA technologies in question differ from those used in standard forensic DNA laboratories. These instruments are sample-to-answer, meaning that after providing a DNA sample, the analysis process is fully automated [47]. In addition, the process of obtaining results takes only two hours as opposed to a two-day average turnaround in forensic labs [47]. The instruments are currently being validated by FBI laboratories [48]. Proponents of the bill focus on the enhanced timescale provided by the technology [49]. This may be particularly important in situations involving a fleeing suspect, which could evolve into an extensive manhunt if the suspect is not immediately arrested. Opposition to the act generally falls under two headings. Some argue that expanded access to the CODIS database, as well as the lack of forensic science experts at any point in the process, leave the door open to abuses and misinterpretations that can confound investigations and inconvenience innocent citizens [50]. Others point to the decentralized and fast-moving nature of the technique to highlight increased potential for civil rights abuses [50]. Furthermore, one purported benefit of the technology – reduction of the rape kit backlog – is currently beyond the scope of rapid DNA technology, as the technology is unable to identify individual DNA from a mixture of bodily fluids [50].

How should we govern forensic science?

The future of CODIS

The task of governing the development and application of forensic DNA techniques is divided amongst several entities. The FBI itself has developed quality assurance standards through the DNA Advisory Board, which was established after the passage of the DNA Identification Act of 1994 [51]. Non-profit industry groups, such as the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB) and Forensic Quality Services (ANSI-ASQ National Accreditation Board FQS), perform the actual process of accreditation. To maintain accreditation, all laboratories participating in CODIS must undergo periodic audits, which can be performed by members of external boards, or individuals internal to the laboratory [51]. There is also variation on a state-by-state level regarding standard operating protocols, which are created by state SBIs. Finally, the FBI maintains federal DNA laboratories, which may still be accredited by a non-profit industry group, but uses operating protocols devised at a state level [51]. This hierarchical structure of governance, where neutral third parties enforce specific federal guidelines while allowing for state level discretion regarding operating protocol, seems designed to be robust. However, this has not created a faultless system, as issues have emerged on multiple levels regarding the application of forensic DNA techniques.

Aside from the chronic backlog of samples and broad civil rights issues, several problems have emerged regarding the administration and practice of the science behind forensic DNA testing. One of these problems concerns the significant error rate among forensic DNA laboratories. Promoters of the technology have often portrayed DNA testing as virtually infallible, a trend that was reflected in observations from the National Research Council in 1996 [52].

A closer look at the ways samples are generated refutes this notion. A 2008 study by UC Irvine legal scholar William Thompson described several examples of false-positive hits resulting from standardized database searches [53]. The study also noted the significant human error that can affect the forensic DNA workflow at several points, including contamination and mislabeling of samples. In some cases, these errors were only identified after conviction, demonstrating the power of DNA evidence to alter the outcome of a verdict, as well as the real possibility of errors in the process. An older study, examining anonymous data from forensic laboratories in the first error rate test, found that human error had occurred in 12 out of 1000 tests [54]. To put this figure into context, if these errors are not noticed and corrected before trials, then over 2,700 of the approximately 250,000 cases processed each year might be based on faulty evidence. This error estimate indicates that conclusions drawn from DNA evidence are not infallible, and that more investigation into error rates, and prevention of error, are necessary given the high status DNA analysis is given among law enforcement and in the courtroom.

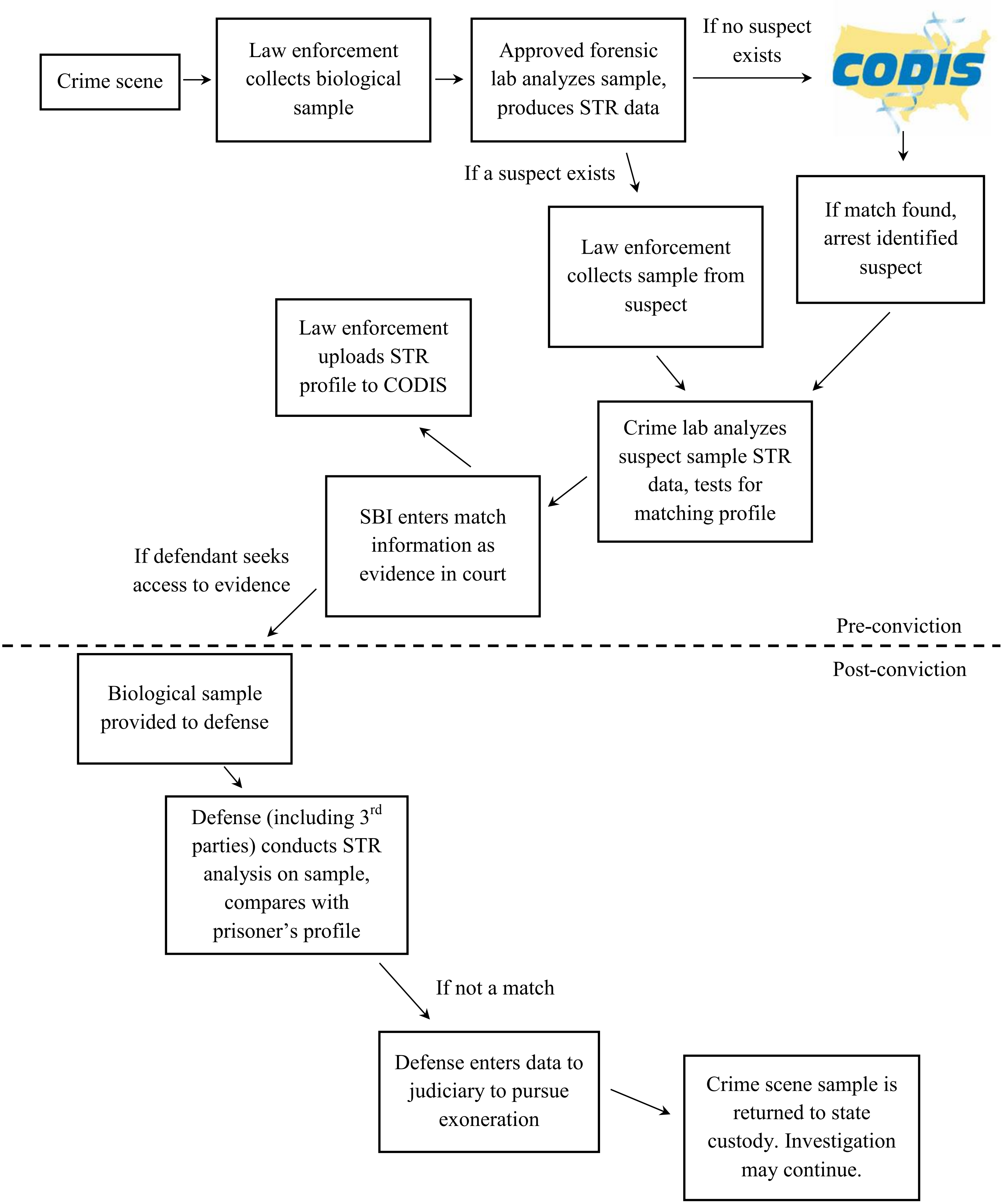
Other scholars have highlighted deeper issues with the science behind forensic DNA applications. One researcher highlighted a growing disconnect between technology development, application by law enforcement, and acceptance by courts. University of Dundee forensic scientist Niamh Nic Daéid noted that a Supreme Court judge in New York dismissed DNA evidence derived from a technology known as low-copy-number DNA testing, which is used to amplify extremely minute samples of DNA [55]. The technique has been criticized for susceptibility to contamination, and the judge declared that there was not enough scientific consensus supporting the technique to validate its use for evidentiary analysis. This was despite the fact that the technology had already been used to reach convictions in other countries. Determining validity of categories of evidence on a case-by-case basis is more likely to lead to inconsistent application of the technology in question, highlighting the need for both increased standardization as well as more communication among forensic technology developers, forensic scientists, and lawyers and judges.

In other cases, existing guidelines have not been followed rigorously, creating opportunities for error. For instance, the FBI relies on 13 loci to ensure that the likelihood of false positive matches is sufficiently low. In 2008, however, the San Francisco Police Department convicted a man based on a five-locus match [56]. Analysts note that given the size of California's sample database, a five-locus match would point to an innocent person approximately one-third of the time [57]. The fact that the court admitted such dubious evidence demonstrates a need for improved policing of adherence to FBI guidelines, as well as better education for members of the judiciary regarding statistical significance and the reasoning behind aspects of forensic DNA processing that may seem redundant and/or obscure to a non-expert.

Even more discouraging are reports of active abuses of DNA evidence. Most infamously, in 2003 a Houston crime lab was found to be functioning at a sufficiently low level as to require a thorough review of all convictions made on the basis of DNA evidence from that laboratory [58]. The lab had few safeguards against contamination, and did not follow professional maintenance or recordkeeping guidelines. More recently, a 2013 investigation by the New York Medical Examiner's Office found that one particular technician had failed to detect biological evidence in a large number of cases in which there was opportunity for the use of DNA evidence [59]. Reanalysis of one of the samples led to an indictment ten years after the evidence had been collected. The technician left her post after this discovery. Finally, the North Carolina State Bureau of Investigation was found to be intentionally withholding evidence, including DNA evidence, in a 2010 investigation [60]. Inconsistencies in reporting the results of certain forensic tests resulted in the withholding of information that might have favored defendants. More than 200 North Carolina cases were affected by this behavior; three of them had already resulted in executions. This scandal led many to question whether the SBI favored prosecutors while fighting off requests from defendants for additional information. These cases are indicative of the surprising ease with which regulations can be flouted and evidence can be manipulated to influence verdicts.

It is evident that the forensic DNA enterprise faces difficult problems regarding the practical administration of the technology, as well as deeper issues regarding the fundamental science behind forensic DNA and potential civil rights infringements. However, the power of forensic DNA to enhance criminal investigations and improve the accuracy and fairness of court proceedings is also apparent. This is a time of transformation and growth for the institutions and regulations surrounding forensic DNA use, as misuses are brought to light and many in the criminal justice system seek to improve the workflow and databases used in forensic DNA testing. These factors indicate that a thorough understanding of the core problems regarding use of forensic DNA, as well as the actors governing and reforming the field, will be essential to shape the application of forensic DNA in the future.

DNA Custody from Crime Scene to Post-Conviction



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