



DNA Forensics:
*Expanding Uses
and Information
Sharing*

September 2006

W. Mark Dale
Owen Greenspan
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NCJ 217992

U.S. Department of Justice

Bureau of Justice Statistics

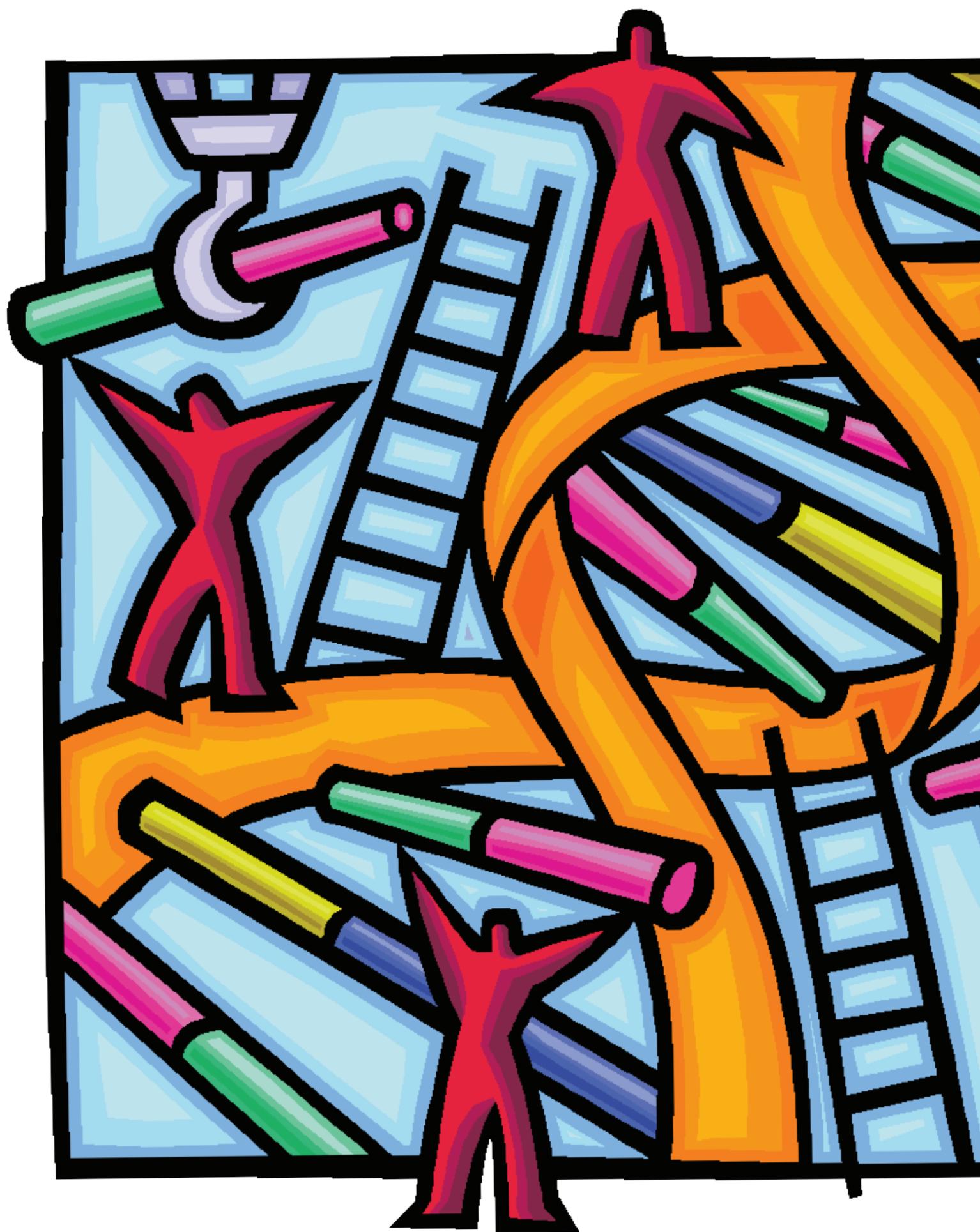
Jeffrey L. Sedgwick, Director

Acknowledgments. This report was prepared by SEARCH, The National Consortium for Justice Information and Statistics, Francis X. Aumand III, Chairman, and Ronald P. Hawley, Executive Director. Owen M. Greenspan, Director, Law and Policy, of SEARCH, project director and author, W. Mark Dale, Director of the Northeast Regional Forensics Institute (NERFI) at the University at Albany, State University of New York and Donald D. Orokos, Instructor in Biology and Associate Director, Forensic Molecular Biology Program at the University at Albany, State University of New York, authors. Dr. Gerard F. Ramker, Chief, National Criminal History Improvement Programs, Bureau of Justice Statistics, Federal project monitor.

This report was produced as a product of a project funded by the Bureau of Justice Statistics (BJS), Office of Justice Programs, U.S. Department of Justice, under Cooperative Agreement No. 2006-BJ-CX-K013, awarded to SEARCH Group, Incorporated, 7311 Greenhaven Drive, Suite 145, Sacramento, California 95831. Contents of this document do not necessarily reflect the views or policies of BJS or the U.S. Department of Justice. Copyright © SEARCH Group, Incorporated, dba SEARCH, The National Consortium for Justice Information and Statistics, 2006.

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Preface

The value of DNA in verifying identities, excluding suspects, and solving crimes—particularly those that have gone unsolved for years—has far exceeded the expectations of those who first noticed its forensic potential more than 20 years ago. *DNA Forensics: Expanding Uses and Information Sharing* was prepared to inform the broad justice community about the evolution of DNA identification and its expanding uses.

The report examines the history of DNA use by forensic investigators, considers the economics of DNA use as it relates to public safety, and reviews privacy concerns relating to the release of an individual's genetic information. The report explores issues associated with the coupling of criminal history information with DNA data and recommends that mechanisms be put in place that would make for a more efficient justice system while effectively continuing to address privacy concerns.

The report utilizes some terms that may not be familiar to those not associated with the DNA forensics community. Therefore, this report includes a glossary to assist readers.

Dramatic advances in DNA forensics will continue to propel this once-exotic science into more mainstream criminal justice applications, perhaps even allowing it to someday replace the fingerprint as the primary tool for verifying identities. It is hoped that this report allows readers to understand how these developments have occurred, and to monitor the progress of DNA forensics in a more informed capacity.



Glossary

While the science of DNA is replete with complicated concepts, components, and procedures, this report was written with the layman in mind; thus, scientific jargon was kept to a minimum. However, it would be difficult, if not impossible, to write a report such as this without including some of the terminology common to forensic DNA use. The following list is provided to assist readers in understanding the processes through which forensic investigators use DNA to identify perpetrators when traditional crime-solving methods have failed.

ABO blood typing

A human blood-typing test that uses antibodies from bodily fluids to determine whether an individual has A, B, O, or AB type blood. ABO typing was commonly used in the past, before the implementation of DNA analyses.

Combined DNA Index System (CODIS)

An electronic database of DNA profiles obtained from unsolved crimes and from individuals convicted of particular crimes. CODIS contributors include the Local DNA Index System (LDIS), the State DNA Index System (SDIS), and the National DNA Index System (NDIS). CODIS is maintained by the FBI.

Deoxyribonucleic acid (DNA)

A nucleic acid that contains genetic instructions for the biological development of all cellular forms of life. DNA is responsible for most inherited traits in humans. Forensic scientists use DNA from blood, semen, skin, saliva, or hair recovered from crime scenes to identify possible suspects through DNA profiling, during which the length of repetitive DNA sections are compared. An individual's DNA is unique except for identical twins.

DNA polymerase

An enzyme that assists in DNA replication.

Electrophoresis

A process that occurs when molecules placed in an electronic field migrate toward either the positive or negative pole according to their charge. The process is used to separate and sometimes purify macromolecules that differ in size, charge, or conformation. Electrophoresis is one of the most widely used techniques in biochemistry and molecular biology.

Mitochondrial DNA (MtDNA)

Differs from nuclear DNA in location, sequence, quantity in the cell, and mode of inheritance. MtDNA is found in a cell's cytoplasm and is present in much greater numbers than nuclear DNA, which is found in a cell's nucleus. In humans, MtDNA is inherited strictly from the mother. It is useful in identifying individuals in areas not conducive to nuclear DNA analyses, such as when nuclear DNA cannot be obtained in sufficient quantities or quality. Also, MtDNA use in identification is less efficient than nuclear DNA analysis in that it cannot differentiate between individuals who share the same mother. The statistical probabilities for identification from MtDNA are not as unique as nuclear DNA.

Polymerase Chain Reaction (PCR)

A process through which millions of copies of a single DNA segment are produced in a matter of hours without using living organisms like *E. coli* or yeast. The process relies on several basic components, including a DNA template, which contains the DNA segment to be amplified; two primers, which determine the beginning and end of the region to be amplified; DNA polymerase, which copies the region to be amplified; Deoxynucleotides-triphosphate, from which the DNA

polymerase builds the new DNA; and a buffer, which provides an appropriate chemical environment for the DNA polymerase. PCR occurs when the components are combined in a test tube, which is then heated and cooled to different temperatures to encourage various chemical reactions.

Restriction Fragment Length Polymorphism (RFLP)

A process through which DNA is cut by restriction enzymes into restriction fragments. The enzymes only cut when they recognize specific DNA sequences. The distance between the locations cut by restriction enzymes varies between individuals, allowing their genetic identification.

Single Tandem Repeats (STR)

Small DNA regions that contain DNA segments that repeat several times in tandem. Repeated sequences are a fundamental feature of genomes, such as DNA, and play an important role in genomic fingerprinting. CODIS uses 13 STR sequences as genetic markers.

Variable Number of Tandem Repeats (VNTR)

Short DNA sequences ranging from 14 to 40 nucleotides organized into clusters of tandem repeats of between 4 and 40 repeats per occurrence. VNTRs cut by restriction enzymes reveal a pattern of bands unique to each individual. They play an important role in forensic crime investigations.

Overview

The application of DNA technology to the biological evidence in criminal casework has revolutionized forensic science. The ability to identify, with a high degree of certainty, a suspect in violent crimes now routinely provides valuable leads to criminal investigators worldwide, often in circumstances where there are no eyewitnesses. Forensic DNA technology is a very sensitive and universally accepted scientific technique. The **Combined DNA Index System (CODIS)**, administered by the Federal Bureau of Investigation (FBI), is a distributed database with three hierarchical tiers enabling local, statewide, and national comparisons among convicted offender profiles and with crime scene samples. As of June 2006, it contains more than 3.3 million convicted offender profiles and more than 142,000 profiles from crime scenes, and has produced 36,000 “investigation-aided” matches in 49 States and 2 Federal laboratories.¹ DNA analysis also benefits the innocent. Suspects may be eliminated before arrest or exonerated even after conviction.

Information is the lifeblood of the criminal justice system. Despite the wonders of DNA science and technology, DNA use cannot achieve its full promise in the context of criminal justice applications unless there are efficient means in place for criminal investigators to obtain the criminal history information of a suspect when a match is made between physical evidence collected at the crime scene and a profile stored in a local, State, or national database. Once the crime lab completes its work, should it report a match, the investigator must learn as much as possible about the suspect. Traditionally, the criminal history record (or “rap sheet”) is a primary source for learning about the nature of the suspect’s past offenses and provides a path to physical description information, a “mugshot” photograph, past modus operandi information, and known associates, and is often of considerable value in locating the suspect.

Privacy advocates have consistently raised concerns about linkages between personal identifying information and an individual’s DNA, which can reveal genetic information about the individual and his/her



family members. This issue has led to policies and practices whereby there is no formal interface between CODIS and any criminal history record information systems. Further, CODIS does not store criminal history information, nor was it designed to include any personally identifying information about the subject of the DNA sample.² States have tended to follow the FBI’s lead in this area. In fact, a number of the State laws expressly prohibit the linking of criminal history record information with an offender’s DNA profile.³

Yet establishing linkages between DNA databases and State and Federal criminal history databases would enable an investigator to know that a suspect’s DNA profile is available for comparison. Perhaps just as important, a linkage mechanism could serve as a flag to indicate that an offender’s DNA sample has *not* been obtained, although required by law. Consequently, the offender’s DNA profile would be unavailable for comparison with material recovered from a crime scene. The challenge for the criminal justice community is to create an environment that efficiently leverages the power of DNA technology, while allowing for sharing (or at least access to) essential information in a manner that respects privacy concerns.

¹ Source: FBI CODIS web site at <http://www.fbi.gov/hq/lab/codis>.

² Letter from Thomas F. Callaghan, Ph.D., Chief, CODIS Unit, FBI Laboratory, to Owen Greenspan, Director, Law and Policy Program, SEARCH, The National Consortium for Justice Information and Statistics, dated June 16, 2005. Hereafter, Callaghan Letter.

³ Ibid.

DNA Collection Legislation

The FBI is responsible for the administration and support of the **National DNA Index System (NDIS)** in accordance with Federal law.⁴

All States have enacted laws requiring the collection of DNA from offenders convicted of specified crimes. Many States are moving to expand the circumstances mandating collection and retention to include more or all convicted felony offenders and some convicted misdemeanor offenders, extending or eliminating the statute of limitations for certain offenses where DNA evidence exists, and even requiring the taking of DNA samples subsequent to arrest but before disposition.

For example, the enactment of California Proposition 69 in November 2004 authorized the collection of DNA samples from adults and juveniles convicted of any felony offense, as well as adults and juveniles arrested for or charged with felony sex offenses, murder, or voluntary manslaughter.

Table 1⁵

Database Criteria	Number of Jurisdictions*
Sex Offenses	55
Murder	54
Offenses Against Children	54
Kidnapping	54
Assault and Battery	53
Robbery	53
Burglary	52
All Felonies	44
Juveniles	31

* The 55 jurisdictions referenced include the 50 States, the District of Columbia, Guam, the Commonwealth of Puerto Rico, Federal Offenders under authority of 42 U.S.C. § 14135a, and persons charged by the U.S. Department of Defense under authority of 10 U.S.C. § 1565.

⁴ 42 U.S.C. § 14132.

⁵ Callaghan Letter.

Effective in 2009, all adults arrested for or charged with any felony offense in California will be subject to DNA sample collection. The trend toward increasing the number and types of designated offenses that require the taking of DNA samples will significantly increase local, State, and national database populations. Table 1 summarizes the frequency with which State laws direct or authorize the taking of DNA samples for certain convictions.

DNA, Economics, and Public Safety

Recidivism is the fundamental factor that provides the underlying rationale for the DNA database program. As noted in a 2003 report on sex offender recidivism:

- “Within 3 years following their release, 38.6% (3,741) of the 9,691 released sex offenders were returned to prison.”⁶
- “The first 12 months following their release from a State prison was the period when 40% of sex crimes were allegedly committed by the released sex offenders.”⁷

The *National Forensic DNA Study Report* found that there is a backlog of over one-half million criminal cases containing unanalyzed DNA evidence.⁸ These cases either have not been sent to laboratories, or are in laboratories awaiting analyses. A 1996 report, *Victim Costs and Consequences: A New Look*, examines the many tangible and intangible costs of crime as it pertains to victims in the United States.⁹ The authors estimate the tangible costs of rape to be approximately \$5,000 per assault. When intangible costs that affect the victim’s quality of life

⁶ Patrick A. Langan, Erica L. Schmitt, and Matthew R. Durose, *Recidivism of Sex Offenders Released from Prison in 1994* (Washington, DC: U.S. Department of Justice, Bureau of Justice Statistics, November 2003) at p. 2. Hereafter, Langan report.

⁷ *Ibid.*, p. 1.

⁸ Nicholas P. Lovrich, et al. (Pullman, WA: Washington State University and London: Smith Alling Lane, February 2004) at p. 3.

⁹ Ted R. Miller, Mark A. Cohen, and Brian Wiersema (Washington, DC: U.S. Department of Justice, National Institute of Justice, January 1996) at p. 1.

are considered, the cost estimate rises to \$87,000 per assault. The report also projects that violent crime leads to 3% of all medical spending and 14% of injury-related medical spending. The aggregate tangible costs of medical spending for rape is \$7.5 billion per year. When pain, suffering, and lost quality of life are considered as well as out-of-pocket expenses, the aggregate annual cost of rape is estimated to be \$127 billion. Personal crime medical costs total \$105 billion per year, with total intangible quality of life costs totaling \$450 billion per year. There is a clear cost benefit for timely DNA analyses for violent crime cases. For example, a Master of Business Administration thesis, “Business Case for Forensic DNA,”¹⁰ discussed how solving sexual assaults with DNA analyses would eventually lessen recidivism and be cost effective.

DNA technology is expensive, but the potential cost benefits are staggering—given both the tangible (DNA analyses and victim’s medical treatment) and intangible (quality of life for victim and community) costs incurred because of crime that can be solved with the aid of DNA technology. The national United Kingdom (UK) DNA database contains 3.5% of its population in the convicted offender index and yields a 40% hit rate. The UK Forensic Science Service’s DNA database of 3 million convicted offender samples not only has the probability of delivering a hit 40% of the time, but it solves .8 additional cases per hit and prevents 7.8 crimes for every hit.¹¹ The UK system operates under a legal system significantly different from that of the United States—it is one that allows DNA collection from arrestees and even in the course of neighborhood sweeps.

¹⁰ Ray A. Wickenheiser, University of Louisiana, Lafayette (2002).

¹¹ Christopher H. Asplen, *The Application of DNA in England and Wales* (London: Smith Alling Lane, January 2004) at p. 1.

The growth in reliance on forensic DNA programs has led to significant casework backlogs in public laboratories. A Bureau of Justice Statistics census of publicly funded forensic crime laboratories, *50 Largest Crime Labs, 2002*, identified compelling data for the ever-increasing caseloads on public DNA laboratories.¹² Only one-third of the DNA cases submitted to public laboratories are analyzed. Most public forensic laboratories can only analyze the most serious cases that are scheduled for court. This leaves potential evidence from many other cases unanalyzed. A study in one State indicated that lesser offense cases provide the majority (81%) of hits in CODIS rather than homicides and rapes.¹³ There is a 1.69 ratio of backlogged to completed DNA cases per year. Simply stated, if a laboratory analyzes 1,000 DNA cases, the same laboratory carries a backlog of 1,690 cases, or 1.69 years of work.

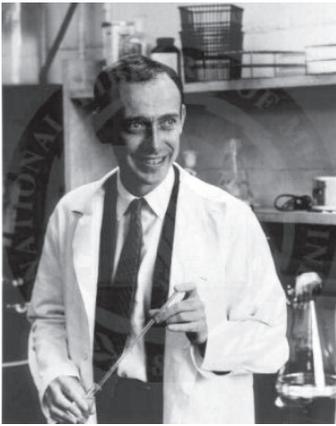


The Science and Evolving Technology of DNA

Comparisons between latent prints left at crime scenes and known fingerprints from suspects had been the traditional method for using physical evidence to place individuals at the scenes of crimes. Manual searching of fingerprint files in the absence of a suspect, known as “cold searching,” was a tedious, challenging, and often impractical process. In the 1980s, with the advent of **automated fingerprint identification systems** (AFIS), police departments no longer needed a suspect. Partial fingerprints recovered from a crime scene could be automatically searched against massive databases of arrest fingerprints with greater accuracy and

¹² Matthew J. Hickman and Joseph L. Peterson (Washington, D.C.: U.S. Department of Justice, Bureau of Justice Statistics, September 2004).

¹³ Virginia Department of Forensic Science, “DNA Database Statistics,” (2005).



James Watson

speed than previously imaginable.

The scientific technology of DNA profiles has added a new dimension to the melding of crime scene evidence with biometric information. DNA technology uses statistical probabilities to determine the rarity of one random person

having a specific genetic profile. This is done using the different sizes of 13 locations (**loci**) found in human DNA. The probabilities of an individual having a unique DNA profile can be one in a billion or more. These probabilities are so rare that they can be used as a statement of identification. Latent fingerprint comparisons rely on the expertise and experience of the latent fingerprint examiner. DNA forensic profiling and comparisons rely on statistical probabilities to determine the uniqueness of the profile.

Over some 20 years, forensic laboratories have evolved from using traditional ABO blood-typing methods to eliminate or include suspects to progressively more efficient methods of forensic DNA analyses. The earlier methods of ABO and electrophoresis could categorically exclude suspects but were of little value as methods for determining positive identification.¹⁴ Today, the newest DNA analysis method—multiplex **polymerase chain reaction single tandem repeat** (PCR STR)—is capable of producing sole-source attribution probability of one in a trillion or more.

¹⁴ J.M. Butler, *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*, 2nd ed. (Burlington, MA: Elsevier Academic Press, 2005). Hereafter, Butler report.

In the early 1950s, James Watson and Francis Crick first described the structure and a possible role for the double-stranded DNA molecule. The first DNA typing technology used successfully in forensic laboratories was originally described in 1985 as “DNA fingerprinting” by Dr. Alec Jeffreys.¹⁵ Dr. Jeffreys recognized that certain regions of DNA contained repeats of the same sequences, and that these repeat regions, or **variable number of tandem repeats** (VNTR), vary in length from one individual to the next. Dr. Jeffreys used a molecular biology technique, referred to as **restriction fragment length polymorphism** (RFLP). At that time RFLP, in conjunction with VNTR, provided a powerful tool for forensic DNA typing. However, it was expensive, time-consuming (6–8 weeks), a safety hazard due to the use of radioactive probes, and required a relatively large amount of intact DNA.

In 1986, a molecular DNA technique known as PCR was developed.¹⁶ PCR helped revolutionize forensic DNA typing by amplifying very small amounts of DNA recovered from crime scenes.

In this highly sensitive amplification technique, a DNA molecule is synthesized and replicated. Each newly synthesized DNA molecule can also serve as template DNA in future cycles, thus producing millions of copies of specific target DNA in a three-hour run. Overall, PCR technology is a sensitive, safe, fast, robust, and economical method. The PCR DNA technology relates specifically to the DNA that is located in the nucleus of human cells. Typically, the majority of crime scene evidence suitable for nuclear PCR DNA techniques is blood, saliva, and semen.



Francis Crick

¹⁵ Alec J. Jeffreys, V. Wilson, and S.L. Thein, “Individual-specific ‘fingerprints’ of human DNA,” *Nature* 316: 76–79 (July 4–10, 1985).

¹⁶ K. Mullis, et al., “Specific enzymatic amplification in vitro: the polymerase chain reaction,” *Cold Spring Harbor Symposium on Quantitative Biology* 51: 263–273 (1986).



A second type of forensic analyses is **mitochondrial DNA (mtDNA)**, which is found outside of the cell nucleus in the cytoplasm. MtDNA is present in much higher volumes and

is less susceptible to environmental degradation. It is also possible to obtain an mtDNA profile from cells without nuclei, such as hair shafts. This type of DNA is helpful in severely degraded evidence, such as decomposed tissue and bone. However, the statistical probabilities derived from mitochondrial analyses are not as unique or rare as nuclear DNA at present and the technique is costly and time-consuming. It is hoped that automation and efficiencies gained from economies of scale will decrease the cycle time and costs, and increase the uniqueness of the statistical probabilities of this very useful technique.

MtDNA testing has been popularized owing to its ability to provide results when other specimens may not yield typical nuclear DNA results. For example, with highly charred remains, it is oftentimes not possible to obtain a full profile using other methods. However, with this approach it is frequently possible to recover a sufficient quantity of mtDNA for analysis. Further, even degraded specimens, either through environmental insults or exposure to chemical challenges, can produce a mitochondrial DNA profile. MtDNA is also better suited for recovering useful material from dried skeletal remains, older fingernails, and smaller sample sizes than other methods.

Another distinct feature of mtDNA is that it is maternally inherited. When the egg and sperm meet, only nuclear DNA is contributed from the spermatozoon to the fertilized egg. This characteristic can be helpful in forensic cases, such as analysis of the remains of a missing person, where known maternal relatives can provide reference

samples for direct comparisons to the mtDNA profile generated from the questioned remains. A mother passes her mtDNA profile to her children and shares her mtDNA with her mother, her siblings (both male and female), and her biological maternal relatives (male or female). Mitochondrial DNA testing has been successful in identifying soldiers from the Vietnam War and World War II by comparison to distant maternal relatives; identifying remains recovered from historical casework such as those of Tsar Nicholas II and his family; identifying the victims of mass disasters; and identifying missing persons.

Table 2 illustrates the rapid evolution of DNA analysis by the FBI.

Table 2: The Rapid Evolution of DNA Analysis by the FBI

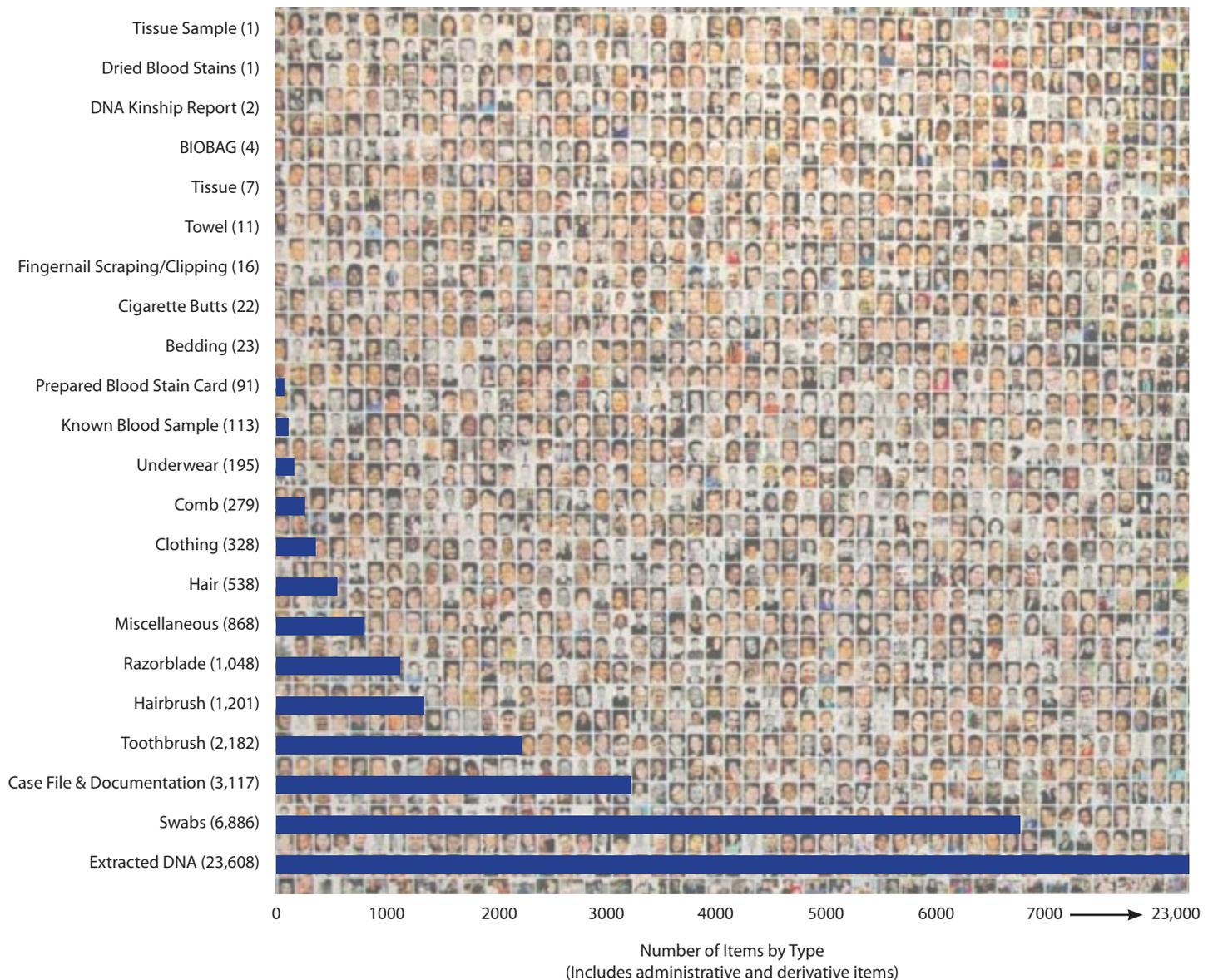
1985	Dr. Alex Jeffreys develops RFLP probes
1988	FBI begins RFLP casework
1993	FBI begins PCR STR casework
1998	FBI initiates CODIS with 13 STR loci
1999	FBI and other labs stop RFLP casework
2002	FBI initiates mtDNA casework
2004	FBI initiates mtDNA regional labs

Forensic labs continue to push the sensitivity threshold even lower by performing PCR amplification on select regions of the DNA molecule. A number of benefits arise as analysis techniques improve. These include high throughput potential and an overall decrease in turnaround time for most DNA typing casework. Before recent improvements in the technology (known as STR/PCR technology, referred to earlier as PCR STR on page 4), attempts in profiling degraded DNA samples usually produced inconclusive results. Now, forensic labs even have some success in obtaining profiles from fragmented and degraded DNA samples at disaster sites such as TWA Flight 800¹⁷ and Swiss Air Flight 111.¹⁸

¹⁷ Jack Ballantyne, "Mass disaster genetics," *Nature Genetics* 15(4): 329–331 (1997).

¹⁸ Butler report.

Figure 1: Personal Effects of World Trade Center Victims Collected for DNA Analysis



The World Trade Center (WTC) disaster of September 11, 2001, presented the forensic science community with the challenge of analyzing a large number of seriously degraded victim samples. Developing profiles from victims of the WTC with **single nucleotide polymorphism (SNPs)** and mitochondrial technology lowered the sensitivity threshold bar even further. Personal effects from victims were collected from around the world to analyze and compare to victim DNA profiles (see Figure 1).¹⁹ It was agreed by the New York City Office

of the Chief Medical Examiner (NYCOCME) and the New York State Police (NYSP) that the personal effects would be analyzed at the NYSP Forensic Investigation Center in Albany. The NYCOCME would analyze the victim samples. The two agencies also worked together to design and implement an evidence bar code tracking system and an intralaboratory network to compare victim and personal effect profiles. On April 3, 2005, four years and at least \$80 million later, this unprecedented identification effort ended. Of the 2,749 victims, 1,592 were identified by a variety of forensic techniques. Only 111 identifications were made

¹⁹ President's DNA Initiative, *Lessons Learned From 9/11: DNA Identification in Mass Fatality Incidents*, NCJ 214781 (Washington, D.C.: U.S. Department of Justice, National Institute of Justice, September 2006) at p. 59.

in the last 2 years from the 19,915 tissue samples recovered from the WTC site. The remaining samples have been archived in climate-controlled storage awaiting even more sensitive DNA techniques in the future.²⁰

The latest forensic technology that shows considerable promise in exploiting greater sensitivity in DNA typing is **low copy number** (LCN). Armed with this latest technology, forensic scientists in the near future may be able to routinely obtain a complete DNA profile from only a suspect's fingerprint.²¹ Skin cells from a latent fingerprint can yield a DNA profile. An unidentifiable latent fingerprint could then be used to identify a suspect at a crime scene through the use of DNA. The DNA profile from the latent print could also be used to add probative weight to a latent print that is identified to a suspect. There are also partially degraded DNA profiles that could be compared to a suspect's CODIS DNA if the law enforcement agency has established identification with fingerprints.

In the future, we may see well educated and highly trained investigators or forensic scientists arrive at a crime scene equipped with an ultramodern hand-held "laboratory on a chip" DNA profiling device. Researchers are already in the early stages of validating such prototypes of a portable DNA profiling unit.²² It is a short leap to envisioning the possibility of recovering physical evidence and processing it on-site. At the crime scene, a DNA profile will be produced, and through interface with flagged criminal history databases, the case detective is informed of the identity of a prime suspect.

Legal Strategies to Obtain DNA Samples

A DNA sample can be obtained by any of four basic legal strategies:²³

Voluntary

A suspect may be asked to voluntarily submit a DNA sample to be compared to a casework forensic sample. A blood draw was originally used for the sample, but now it is more common to use a **buccal swab**: a small toothbrush or cotton swab that is rubbed against the inside of the cheek to collect inner-mouth epithelial cells for DNA analyses.

Court Order

A court determines that there is reasonable cause to authorize a law enforcement agency to collect a DNA sample from a suspect for comparison to a forensic sample.

Law

A statute authorizes the collection of a DNA sample from a defined group of individuals, such as convicted offenders or arrestees, for inclusion in the State DNA database.

Abandonment

The suspect gives up control and possession of an item that contains his DNA. For example, a cigarette butt is smoked by a suspect and then discarded. A detective observes the suspect abandon the cigarette butt and leave the immediate area. The detective recovers the cigarette butt.

²⁰ Eric Lipton, "At Limits of Science, 9/11 ID Effort Comes to End," *New York Times*, April 3, 2005, Section I, Page 29.

²¹ F. Alessandrini, et al., "Fingerprints as evidence for a genetic profile morphological study on fingerprints and analysis of exogenous and individual factors affecting DNA typing," *J. Forensic Science* 48(3): 1-7 (2003); and A. Barbaro, et al., "Anonymous letters? DNA and fingerprints technologies combined to solve a case," *Forensic Science International* 146 Suppl: S133-S134 (2004).

²² Cheuk-Wai Kan, et al., "DNA sequencing and genotyping in miniaturized electrophoresis systems," *Electrophoresis* 25: 3564-3588 (November 2004).

²³ Steve Hogan, Deputy Counsel, New York State Police, personal conversation with Mark Dale, Director, Northeast Regional Forensic Institute, May 25, 2005.

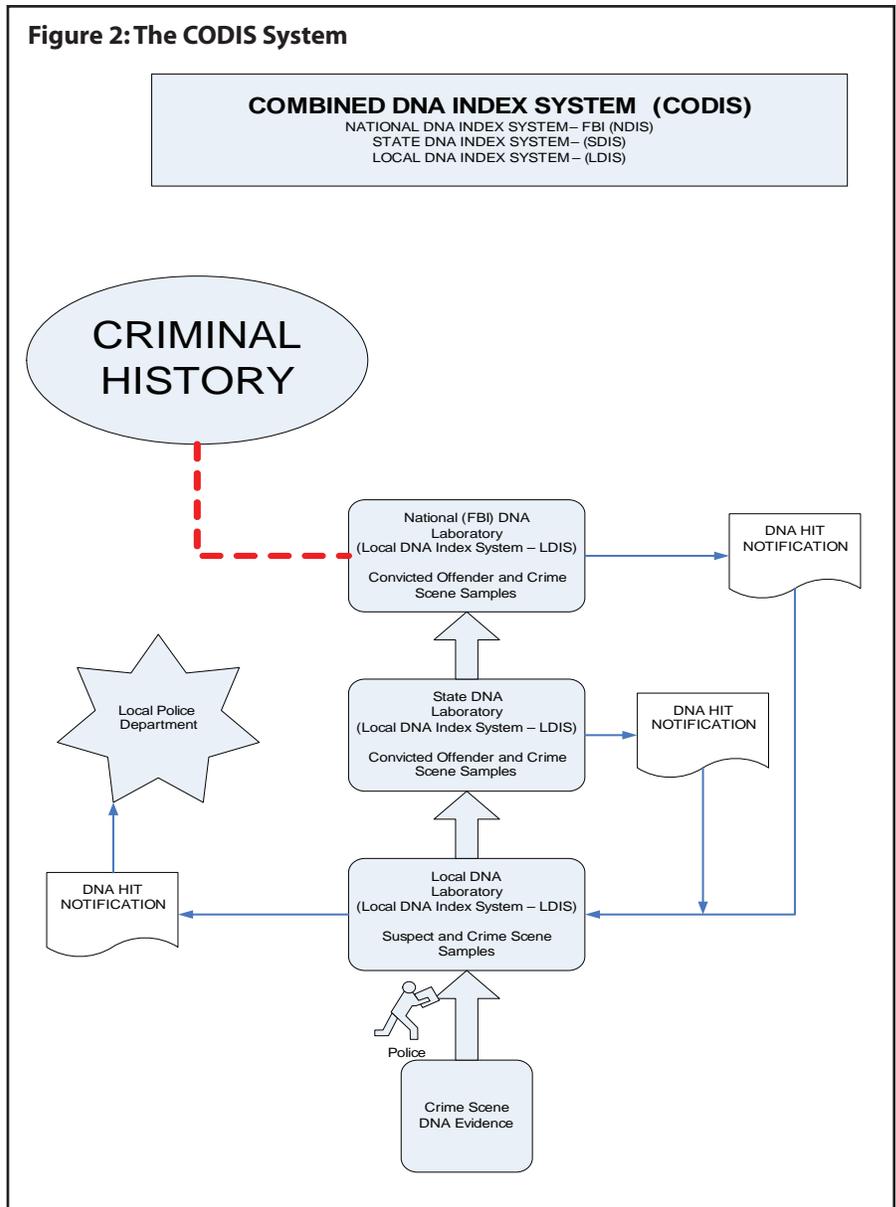
CODIS: The Combined DNA Index System

Sponsored by the FBI, the Combined DNA Index System—CODIS—began as a pilot project with 14 participant State and local laboratories in 1990. Today, the FBI Laboratory’s CODIS Unit is responsible for the software used by 177 Federal, State, and local forensic DNA laboratories that participate in the National DNA Index System (NDIS), for the operation of the National DNA Index, and for the support of the NDIS Procedures Board. Participation in NDIS is governed by a Memorandum of Understanding between the States and the FBI, as well as NDIS Operational Procedures.²⁴

The primary performance measure for CODIS is a “confirmed match,” commonly referred to as an “Investigation Aided” match, due to the inherent complexity in determining the results that arise from follow-up to the DNA hit report. For example, although a DNA database match may have identified a possible assailant, the police or prosecutor may elect not to arrest due to lack of cooperation from the victim, or because of the time barrier imposed by a statute of limitations, or because further investigation might reveal that the suspect identified through the DNA match could not have committed the crime, but may have had access to the crime scene or related physical evidence.

When a hit occurs in CODIS between laboratories within a State or between profiles contributed from different States, the CODIS Administrator for the State laboratory first confirms the identity and the underlying qualifying offense for which the DNA sample of the convicted offender was taken. In some jurisdictions, the State DNA

Index System (SDIS) laboratory may conduct additional confirmatory analyses of the convicted offender DNA sample. A notification is then made to the two laboratories that they have a hit in CODIS. Laboratories then contact the respective police departments and prosecutors and inform them of the hit. (See Figure 2.) The hit provides reasonable cause to collect a final confirmatory DNA sample from the convicted offender, once identified and located, usually with the assistance of the criminal history record. This DNA sample is then compared to the actual evidence in the case as the final quality control check for the entire CODIS system. The hit could also provide linkage to other unsolved or solved cases.



²⁴ Callaghan letter.

Scientific Advances and Expanded Applications of DNA Analysis

Although the nation's justice system has placed greater emphasis on DNA identification over the past 20 years, in crimes of violence the utility of DNA typing reaches further. The use of DNA testing for linking a suspect to a violent crime, determining serial crimes, reconstructing an accident, and exculpating the innocent is powerful technology. However, DNA is proving to be an ever more remarkable tool as its potential to be applied in other criminal justice-related situations is increasingly being explored. This section explores some nontraditional applications of DNA technology that may assist in investigations today and in the future.

Lesser Offenses

The New York City Police Department (NYPD) leveraged DNA technology to solve crimes not usually associated with DNA analysis, such as burglary, assault, and larceny.²⁵ Conceptualized from data presented in the Bureau of Justice Statistics report *Recidivism of Sex Offenders Released from Prison in 1994*,²⁶ the NYPD Laboratory's Biotracks program is a pilot project focused on one particular geographic area: Queens County. Crime scene response teams were trained to identify probative items that might contain biological evidence (e.g., cigarette butts, clothing, and drink containers with possible saliva) and to submit them to the laboratory for processing. The goals of the Biotracks program were to (1) solve crimes involving the commission of lesser offenses—crimes for which physical evidence is often not collected or, when collected, is not usually subjected to DNA analysis;

and (2) determine the extent to which DNA from these crime scenes could be linked to more serious crimes such as rapes or homicides. The program obtained a hit rate of over 30% and identified linkages between lesser offenses with open rape and homicide cases. Due in part to the success and lessons learned from Biotracks, the New York City Medical Examiner's Office is planning to "vastly expand its forensic biology laboratory, which will ultimately redefine the way difficult-to-solve crimes, such as home burglaries and stolen property offenses, are investigated and prosecuted."²⁷

Table 3 depicts the number of arrests for lesser and violent offenses attributed to the 38 offenders identified in the Biotracks program. The offenders clearly possessed a history of both violent and lesser offenses. Table 4 depicts the prior convictions for the 38 offenders identified in the Biotracks program. There was a clear history of convictions from both lesser offense and violent crimes. Case-to-case linkages were developed between a violent crime and lesser offenses (2004 burglary/1994 rape), and between a burglary and a robbery. The Biotracks program has provided valuable leads for law enforcement that have resulted in arrests and convictions. The 29 arrestees from the Biotracks program resulted in 18 guilty pleas to 27 offenses, while 3 were indicted for 4 offenses each. Eighty percent of these individuals were convicted of violent felonies, one individual for homicide, and one individual for four sexual offenses.²⁸

²⁵ DNA in "Minor" Crimes Yields Major Benefits in Public Safety (Washington, DC: U.S. Department of Justice, National Institute of Justice, November 2004).

²⁶ Langan report.

²⁷ Reuven Blau, "City ME's Office Expands Crime Evidence Duties," *The Chief-Leader* (New York City), September 2, 2005, at p.1.

²⁸ Source: New York City Police Department Laboratory.

Table 3: Recidivism Prior Arrests of Offenders in Biotracks Program

Recidivism Prior Arrests

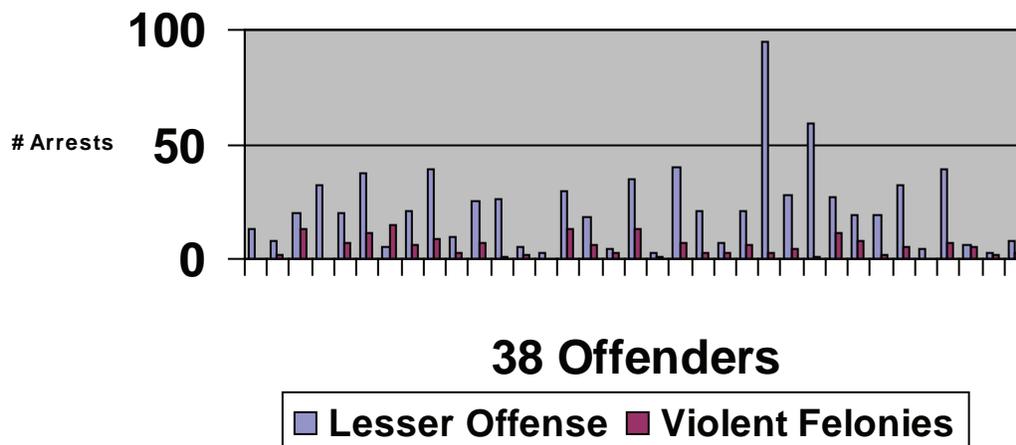
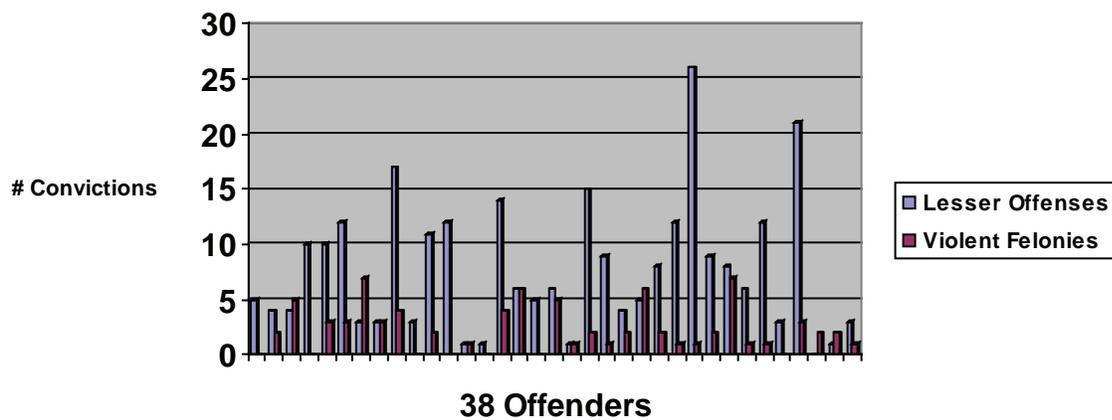


Table 4: Prior Convictions of Offenders in Biotracks Program

Prior Convictions



Feline and Canine DNA

The American Pet Products Manufacturers Association's (APPMA) *2003/2004 National Pet Owners Survey* reports that the number of U.S. pet-owning households has increased by more than 10 million since 1992. Current methods used to identify dog and cat biological material are nuclear STR analysis and mitochondrial (mtDNA) analysis. These techniques use the same procedures that are used by crime laboratories worldwide to identify human biological material. Animal DNA evidence is most often contributed when the animal falls victim to a crime, e.g., shooting death of a dog during a burglary, or when the animal is a companion to a suspect, e.g., shedding of animal hair at the crime scene.

In 2002, Danielle Van Dam was reported missing from her home in San Diego, California. She was found dead in a remote area 25 days later. David Westerfield, the Van Dam family's neighbor, was arrested. Among other evidence, investigators had recovered dog hairs similar to the Van Dams' Weimaraner dog in Westerfield's motor home, on a quilt, and in the lint trap of his dryer. Canine STR typing, performed by the Veterinary Genetics Laboratory at the University of California at Davis, was unsuccessful. An mtDNA match between the evidence hairs and the Van Dam family dog was entered as evidence.

Hair, of both human and animal origin, is a common piece of evidence from a crime scene. Because people and their pets live in close proximity, the recovery of animal hair evidence is quite possible. However, animal hair evidence is often overlooked as a critical form of evidence. Animal hair, in particular, can be found on clothing, in homes, and in cars. Because hair is easily transferred in daily activities, transfer of evidence occurs at every crime scene. The challenge is to identify this useful evidence. The passive transfer of animal hair can show a link to a crime scene. Analysis of canine evidence has been reported in scores of criminal investigations and trials nationwide.

Missing Persons DNA Databases

The University of North Texas Health Science Center has created the Texas Missing Persons DNA Database, an mtDNA database that contributes mtDNA data to the national database for searches of missing persons. The objective of this database is to assist in the identification of kidnapped children, runaway children, and skeletal unidentified human remains. The Missing Persons Clearinghouse for the State of Texas reports that 70,000 people are reported missing each year in that State, with approximately 7,000 active cases at any given time.

A national missing persons DNA database is administered by the FBI. DNA exemplars from missing persons are searched against unidentified human remains. For example, a crime victim's remains are uncovered in a shallow grave, or a deceased victim is found with no form of identification with the body. The DNA from the unknown victim is searched against the missing person DNA data in the hopes of making an identification.

Near-match Searching

Close biological relatives—parents, children, and siblings—are known to often have similar DNA profiles. Near-match searching linked two of the September 11, 2001, American Airlines Flight 11 hijackers as being brothers. Florida has employed near-match searching to identify the fathers of several babies born to rape victims. The Denver District Attorney's Office, in the first case in which the FBI has allowed near-match search information to be shared between States, is using identifying information for a convicted Oregon felon as an investigative lead to try to identify a suspect in a rape case that occurred three years earlier.²⁹

²⁹ Richard Willing, "DNA database can flag suspects through relatives," *USA Today*, August 23, 2006, page 2A.

Is the DNA Match Linked with the Criminal History Record Information?

No. Because an individual's DNA has the potential to reveal genetic information about that individual and his/her family, privacy advocates continue to voice concerns about the proliferation of DNA offender databases and access to the DNA data in those databases. The "eugenics" argument is that genes, unlike fingerprint patterns, contain information about an individual's racial and ethnic heritage, disease susceptibility, and even behavioral propensities.³⁰ Insurance companies, employers, or government agencies might raid the data for health-related information, leading to genetic discrimination against individuals or groups. Behavioral researchers will not be able to resist a database of convicted criminals.

The FBI Laboratory Division sponsored meetings with privacy and defense advocates during the information gathering stages for CODIS. As early as 1991, the FBI laboratory issued "Legislative Guidelines for DNA Databases," stating that "personal information stored in CODIS will be limited ... CODIS will not store criminal history information." The policy of maintaining limited information in CODIS remains today.³¹

A similar policy has been adopted by many States. Illustrative of State DNA databases laws are:

- The California Penal Code provides that "DNA and other forensic identification information retained by the Department of Justice ... shall not be included in the state summary criminal history information."³²

- A Florida statute provides that "any analysis, when completed, shall be entered into the automated data maintained by the Department of Law Enforcement ... and shall not be included in the state central criminal justice information repository."³³
- A Rhode Island law provides that "all DNA typing results and the DNA records shall be stored in a computer database after all personal identifiers have been removed."³⁴

Clearly, there is considerable agreement at both the national and State levels that it is inappropriate to include personal information in DNA databases, including criminal history record information that typically includes physical, biographic, and other descriptive data.

Is the Criminal History Record Information Linked with the DNA Match?

Again, the answer is no. In May 2005 none of the 31 State criminal history repositories responding to a survey by SEARCH, The National Consortium for Justice Information and Statistics, reported making provision for the inclusion of a subject's DNA profile on the criminal history record. However, 13 of the 31 States reported employing a flag on the criminal history record to indicate that a sample had been collected, including 6 States that indicate whether the profile is located on a local, State, or national database.³⁵

³⁰ Simon A. Cole, "Fingerprint Identification and the Criminal Justice System: Historical Lessons for the DNA Debate," in *The Technology of Justice: DNA and the Criminal Justice System*, David Lazer (ed.) (Cambridge, MA: John F. Kennedy School of Government, Harvard University, June 2003) at p. 19.

³¹ Callaghan letter.

³² California Penal Code § 299.5(d).

³³ Florida Statutes § 943.325(1)(d)(6).

³⁴ Rhode Island General Laws § 12-1.5-10 (1).

³⁵ The 13 States were California, Illinois, Kansas, Kentucky, Maine, Michigan, New Jersey, New York, Oregon, Pennsylvania, South Carolina, Tennessee, and Washington.

It is not surprising that a reference to personal identifying information is found on the rap sheet. State criminal history records typically include an identification segment with a provision to record and display some, if not all, of the following personally identifying descriptive elements:

- Name
- FBI Number
- State Identification Number
- Correctional Number
- Social Security Number
- Miscellaneous Identification Number
- Driver's License Number
- Place of Birth
- Date of Birth
- Country of Citizenship
- Sex
- Race
- Height
- Weight
- Eye Color
- Hair Color
- Skin Tone
- Fingerprint Pattern
- Photo Available
- Scars, Marks, and Tattoos
- Employment Information
- Residence

In its December 1995 report, the National Task Force on Increasing the Utility of the Criminal History Record (Criminal History Utility Task Force) recognized the growing use of DNA evidence in criminal cases and the emergence of databases of DNA information. Among its recommendations, the Task Force proposed that a data element be added to the identification data on the criminal history record to indicate the existence and location of DNA samples or profile data. For this data element, location would be indicated by the name and the Originating Agency Identifier (ORI) of the agency holding the information.³⁶

In 1996, the Joint Task Force (JTF) on Rap Sheet Standardization, with representation from the FBI Criminal Justice Information Services Division and its Advisory Policy Board, the National Law Enforcement Telecommunications System, and SEARCH, was formed to implement the recommendations of the Criminal History Utility Task Force by developing a standardized criminal history format for interstate transmission. After much discussion, the JTF opted to establish an element that allows for two kinds of reporting relating to DNA. First, the most common and useful is to report that a DNA sample has been taken from the subject, has been coded, and is available from a specific agency. Second, and not normally included in a criminal history response, is the optional ability to transmit the actual detail of the DNA profile. The latter capability was included should implementations evolve that would be facilitated by the transmittal of the detail code.³⁷ Some States that have yet to adopt the standardized criminal history record have instead opted to note on the rap sheet when an inmate has been convicted of a designated offense, and if a DNA profile is available in CODIS.³⁸

³⁶ SEARCH, The National Consortium for Justice Information and Statistics, *Increasing the Utility of the Criminal History Record: Report of the National Task Force* (Washington, DC: U.S. Department of Justice, Bureau of Justice Statistics, December 1995).

³⁷ This specification is available at <http://it.ojp.gov/jsr/common/list1.jsp?keyword=1&forlist=1&community=yes>.

³⁸ Source: New York State Division of Criminal Justice Services, 2005.

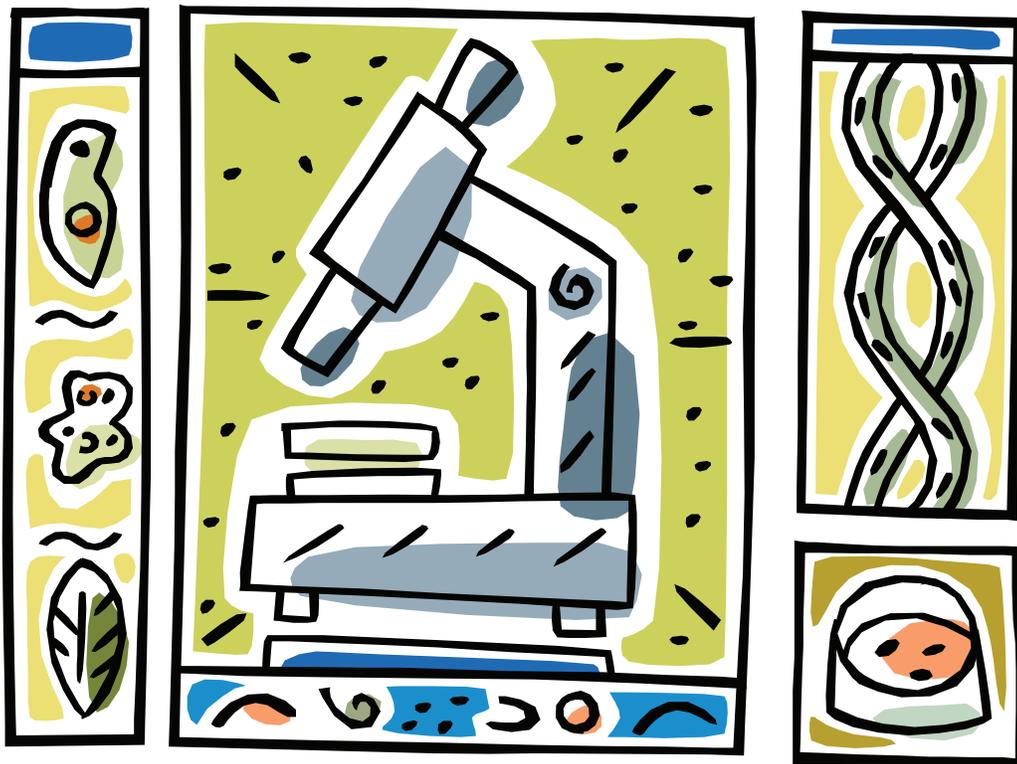
Sharing Information between CODIS, AFIS, and Criminal History Systems: Potential Benefits

The technologies of the DNA database (CODIS), fingerprint comparison (AFIS), and criminal history record systems are highly effective, albeit costly, tools for law enforcement. A detective no longer needs to identify a suspect before a latent fingerprint recovered from a crime scene is compared against a file of fingerprints of persons previously arrested in the jurisdiction, State, or nation. These automated searches and comparisons have become routine. The exchange of limited information among CODIS, AFIS, and criminal history records would provide law enforcement with the awareness that potential probative forensic evidence exists that involves a convicted or arrested offender.

Benefits derived from increased connectivity among different forensic technologies should be explored further. Of major benefit is the potential to increase the accuracy, timeliness, and utility of information

provided to the criminal justice community. More hits, more exclusions, and a higher certainty of identification can be realized by combining two identification technologies (CODIS and AFIS) with criminal history databases.

Legislation authorizing the expansion of DNA databases to include new offenses often includes two components. The first is an effective date at which time all persons convicted of the new offenses are required to provide a DNA sample. The second provision may be retroactive and requires the police to have knowledge of past convictions for the newly authorized offenses. An accurate identity and criminal history of the offender is critical for the acquisition of the DNA sample. Technology can provide an electronic comparison of the databases (criminal history, CODIS, and AFIS) to identify who is required to provide samples, and who has already provided samples for the database. This connection of the AFIS, CODIS, and criminal history databases is even more critical when applied to violent crime and sexual offender registries. Law enforcement can then work more efficiently and accurately to obtain DNA samples, providing more timely leads to criminal investigators.



Conclusion

The power of DNA technology both identifies and excludes suspects. In criminal justice applications, the data contained in the DNA profile is held separate and apart from the identification and other information, which constitute the criminal history record, a circumstance that reflects broad-based privacy concerns about the potential for misuse of DNA profile information. While there is clear consensus that personally identifying information should not be present in DNA databases, it is that very identifying information that an investigator needs to connect the DNA match to a suspect.

The inclusion of DNA profile availability and location information within the criminal history record holds out the promise of several significant operational and public safety benefits. If a suspect has a DNA profile on the State DNA database and the evidence in that case has been entered into the database with no resulting matches, then law enforcement may need to consider directing investigative efforts elsewhere. Knowledge that a DNA sample has not been provided when one is statutorily required is also beneficial, as it will promote the collection of samples without which a correspondent reduction in public safety could occur, or more recidivistic crimes remain unsolved.

Mechanisms for coupling criminal history information with select information about the availability of DNA data are readily available but have not been widely implemented—to the detriment of a more efficient justice system. The Interstate Criminal History Transmission Specification provides for an indication on the rap sheet that a DNA sample has been taken from the subject, has been coded, and is available from a specific agency. Similarly, several States, without implementing the transfer of standardized criminal history, have opted to flag the rap sheet with some or all of this information.

At its December 2005 meeting, the FBI Criminal Justice Information Services (CJIS) Advisory Policy Board (APB)³⁹ recommended to the FBI Director several enhancements to address the inclusion of DNA flags within the Interstate Identification Index, the national criminal history record exchange system administered by the FBI, including:

- (1) allowing States to flag whether a subject's DNA profile is registered, and where that profile is located;
- (2) allowing a DNA indicator to be used to indicate that DNA profiles are available at both the State and national levels;
- (3) a proposed protocol for the FBI Laboratory Division to inform the Criminal Justice Information Services Division of Federal convicted offender DNA registration status data; and
- (4) the inclusion of DNA indicator information on the criminal history record information response to select inquiries.

In sum, these approaches respect privacy concerns by keeping the barrier in place that prevents criminal history information and other personally identifying information from being included in DNA databases, while at the same time enhancing investigative capabilities through a more informative criminal history record.

³⁹ The FBI CJIS APB is chartered under provisions of the Federal Advisory Committee Act of 1972 to advise the FBI Director on criminal justice information services issues. The APB is comprised of a network of working groups and subcommittees. The members represent local, State, and Federal law enforcement and criminal justice agencies throughout the United States, its territories, and Canada. Source: *CJIS Advisory Policy Board Advisory Process Information Handbook*, 2005.

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