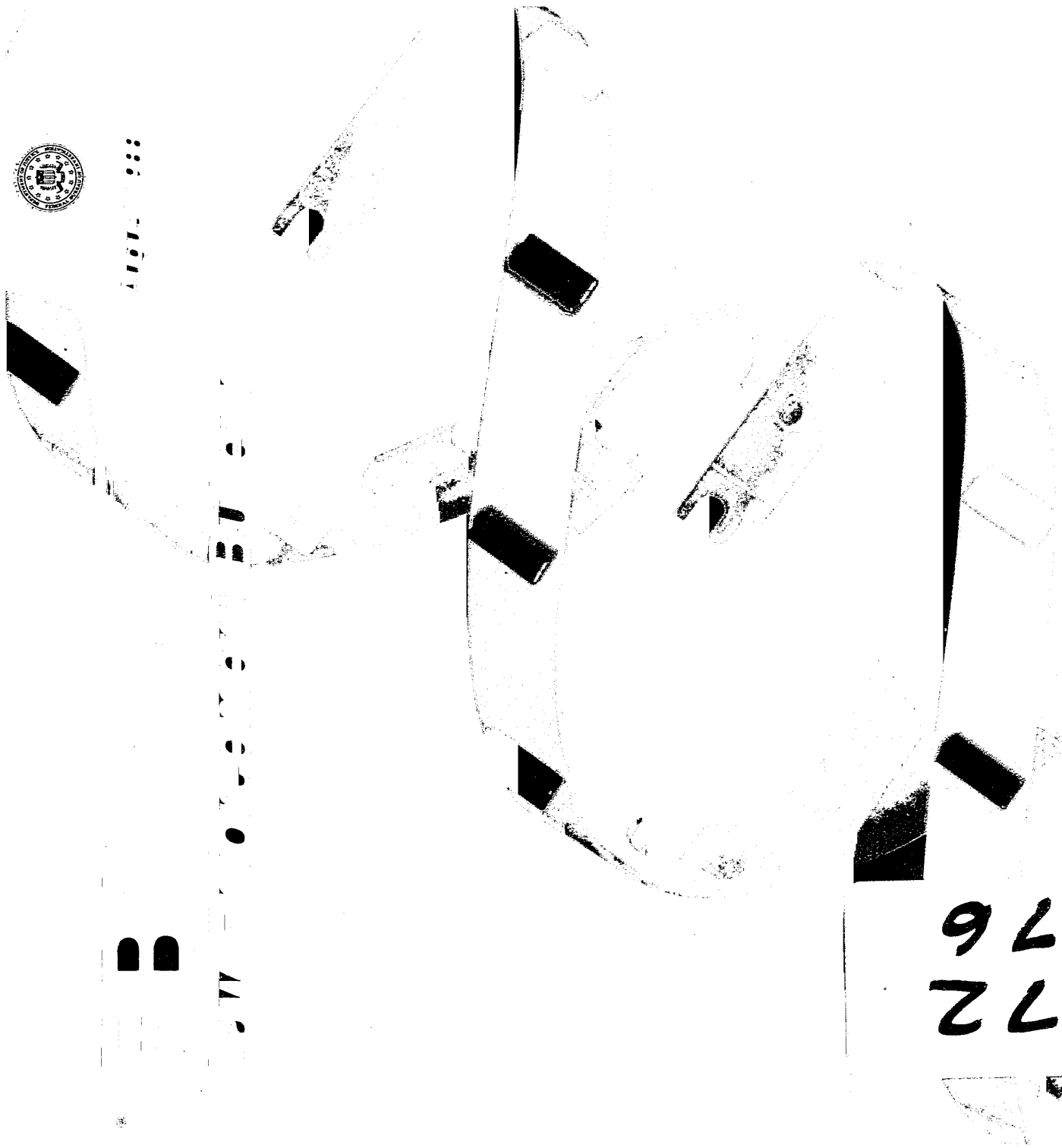

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# DNA Profiling
## A Tool for Law Enforcement

***"Advances in DNA technology represent perhaps one of the most significant forensic breakthroughs of the century. . . ."***

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Consider the following scenarios:

—Police investigating the brutal slaying of a young woman in a southeastern town carefully collect physical evidence at the scene and submit it to their local crime laboratory. Forensic analysis reveals the presence of semen from which a DNA identification profile is determined. This profile is searched through a computerized data bank and a "hit" is made with DNA profiles from similar crimes which occurred months earlier in two northeastern cities. Investigators from these jurisdictions share investigative data, and a suspect is developed. A blood sample obtained from the suspect reveals the same DNA profile, which conclusively identifies him with the semen recovered from the three murder victims.

—The partially decomposed body of a child is found in a rural area. From samples of hair and tissue taken from the remains, a DNA identification profile is made for comparison with DNA profiles of parents of reported missing children.

—Semen is identified on swabbings taken from a rape victim by the attending physician and submitted for analysis, which results in a DNA identification profile being developed. The profile is searched through a central DNA profile data bank and a "hit" is made. The rapist is identified as a resident of an adjacent State who had been convicted 3 years earlier on a burglary charge.

Recent breakthroughs in DNA technology are expected to provide investigators with powerful forensic tools to help solve these difficult kinds of cases.

Personal identification has always been of vital concern to law enforcement. In support of this need, the crime laboratory's primary mission is to apply science to develop information from material recovered from a crime scene, which will identify the perpetrator or associate the perpetrator with the victim or the scene of the crime.

*Deputy Assistant Director Hicks*

The evidentiary materials most frequently recovered in the investigation of a violent crime, such as homicide or rape, are blood, hair, and semen. According to a study conducted in 1984, investigators in many jurisdictions recover these types of evidence more frequently than fingerprints.[1] However, until recently, the forensic analyst has been able to make only limited associations using biological material. DNA technology now provides the analyst with the ability to identify a particular individual based on a drop of blood or semen, or a single hair. Because of its capability to individualize, it is very often referred to as "DNA fingerprinting."

### What is DNA?

Deoxyribonucleic acid (DNA) is an organic substance found primarily in the nucleus of living cells. It comprises the chromosomes within the nucleus and provides the genetic code which determines a person's individual characteristics. The code is expressed by the arrangement of four basic building blocks, called nucleotides, which are represented by the letters A (adenine), G (guanine), C (cytosine), and T (thymine). These nucleotides are linked in chain-like sequences, and their order can vary to provide an almost infinite number of possible arrangements. There are about 3 billion nucleotides in the entire human genetic code.

One of the techniques scientists use to characterize the DNA found in body fluids and tissue specimens is referred to as restriction fragment length polymorphism (RFLP). Special proteins are used to cut the DNA being analyzed at specific sites. These proteins are called restriction enzymes and recognize specific short sequences of four to eight nucleotides, referred to as restriction sites. The restriction sites of greatest value to the forensic scientist are those which are highly variable in the human population (polymorphic). This cutting process results in fragments of DNA of various lengths; hence, the name restriction fragment length polymorphisms. These fragments are then separated on a gel-covered glass plate by a process called electrophoresis. By using other pieces of DNA of known sequence called probes, the analyst can identify the locations on the plate of the DNA fragments of interest. This typically results in a pattern of bands which can then be transferred to photographic film to be interpreted by the analyst.

This a very brief description of the DNA testing process, and there are other methods which are used to characterize DNA.[2] Many different restriction enzymes and DNA probes can be used, and each results in a different banding pattern and provides individual discriminating powers of different values. Because of these variations in test procedures, scientists are now unable to compare test results directly. The ability to classify such information, catalog it, and later search it against other test results is critical for law enforcement use.

### The FBI Role

The FBI has initiated an aggressive forensic research program to develop this technology for eventual implementation in the FBI Laboratory. An ambitious technical training program

***"A national coordination effort is essential if the full law enforcement potential of DNA technology is to be realized."***

is also being developed to instruct personnel of State and local crime laboratories throughout the United States on the use of this technology. The FBI research effort is directed not only at methods development but also at establishing the scientific validity and reliability of these methods to insure that evidence derived from the forensic analysis of DNA can withstand legal challenges to its introduction in the courts.

DNA technology is expected to impact substantially not only the crime laboratory in implementing the technique but also the way certain types of violent crimes are investigated. Classifying systems are now being explored which will allow the DNA profile identifying information to be entered into a centralized computer data bank.

As in the situations described at the beginning of this article, semen collected from victims of unknown subject sexual assault cases might be analyzed and the DNA profiles compared with similar cases stored in the data bank. This would permit definitive linking of similar crimes in one or several jurisdictions, which might not otherwise appear related, thereby facilitating the coordination of leads and other investigative information.

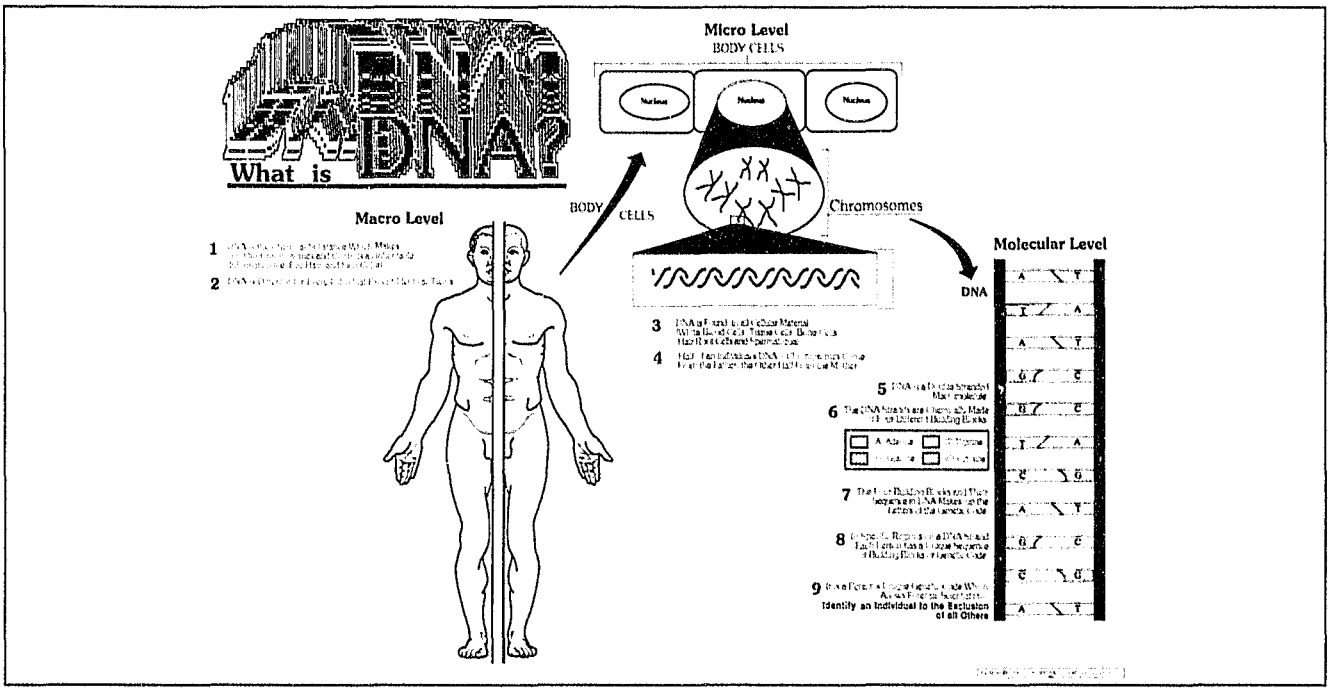
Legislation has been proposed in a few jurisdictions which provides for blood samples to be taken for genetic typing from convicted sex offenders as a condition of paroled release. Such a file would provide a reference against which blood, semen, or hair from the scene of a subsequent crime might be searched. There is also the potential for the establishment of civil files containing voluntarily furnished DNA profiles of individual citizens which might be used to aid in the identification of human remains at the site of a mass disaster.

DNA profiling would be useful to the medical examiner tasked with the identification of unidentified remains. The deceased's DNA profile might be retained for comparison with DNA profiles of the parents or children of missing persons to accomplish an identification through paternity-type DNA testing.

Each of the above concepts, as well as others which might be developed for the application of DNA technology to law enforcement problems, would require the understanding, interest, and support of the user community. The user community is broad and includes crime laboratories, police departments, sheriff's offices, medical examiner's offices, district attorney's offices, and others. A national coordination effort is essential if the full law enforcement potential of DNA technology is to be realized.

### Implementation Strategy

A seminar on DNA technology held in June 1988, at the Forensic Science Research and Training Center at the



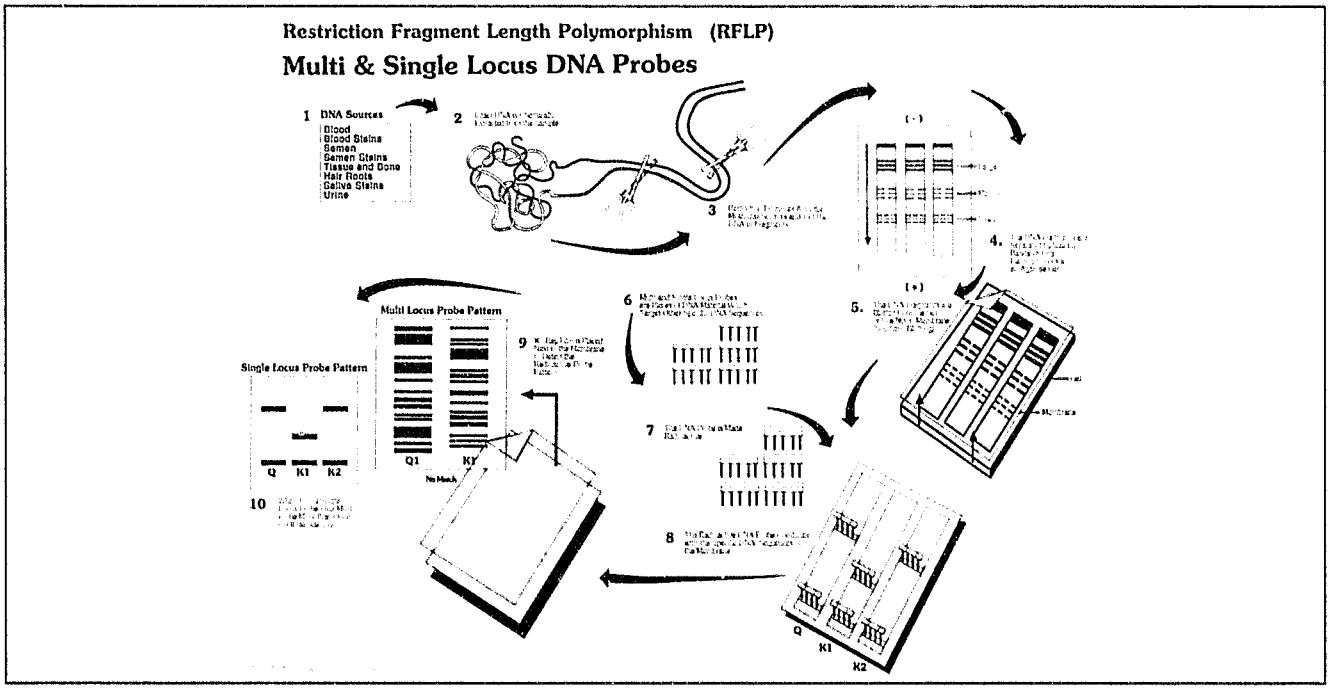
***"A national commitment to the routine use of DNA technology by police agencies at all levels will result in a more efficient and effective law enforcement system."***

FBI Academy in Quantico, VA, was attended by key forensic and medical researchers from academia, the private sector, and the international crime laboratory community. Two important topics addressed at the meeting were the establishment of DNA standards within the forensic science community and the utility and feasibility of automated data files containing DNA identification profile information. Clearly, it is advantageous to law enforcement on a national scale to coordinate the development of these kinds of systems with the establishment of appropriate controls and standards to permit the effective exchange of DNA identification profiles. To accomplish this, the community must agree upon standards which provide a common language and reference bases to facilitate the exchange of critical investigative information. The system must at the same time permit flexibility to accommodate changes as DNA technology continues to evolve. The success of this effort will depend heavily on strong professional commitment to the needs of law enforcement, along with a spirit of cooperation and mutual support within the forensic community.

Steady progress is being made in transferring this important technology to the crime laboratory community. In April 1988, the FBI extended invitations to directors of crime laboratory systems throughout the United States, requesting them to nominate individuals to participate in a visiting scientist program at the Forensic Science Research and Training Center. This 4-month program is designed to provide the technical resources to address the validity and reliability issues associated with DNA testing as quickly as possible. Upon completion of a research project, worked in collaboration with FBI scientists, participants will have developed technical proficiency in the test methods and will have obtained valuable experience in applying DNA implementation efforts in their individual State and local laboratories. A specialized technical training course is being developed for State and local laboratory personnel which will be offered in the fall of 1988. This course, in conjunction with other studies, will also facilitate the introduction of DNA test methods at the local level.

It is anticipated that within 2 to 3 years, DNA testing will be performed fairly routinely on evidence samples. There is an extremely high level of interest in this technology, and if the demand is to be satisfied, agency administrators must take the necessary action to provide the necessary technical personnel and equipment resources.

When forensic DNA testing was initially introduced into this country, the tests were performed at only a few private testing laboratories. During the transition period, as the technology is



transferred to the Nation's crime laboratories, there will continue to be only a limited number of facilities capable of performing these tests. This will necessitate a high degree of selectivity as to which evidence samples are submitted for DNA analysis. Considerations might include an assessment of the probative value of the item of evidence, the size and condition of the evidence stain or specimen, and possible delays which might result in the judicial proceedings while waiting for test results. A physical evidence evaluation and appraisal may show that traditional forensic testing can provide sufficient information that would preclude the need for DNA tests.

### Considerations

While DNA technology will provide a powerful new capability for law enforcement, it will not necessarily displace the forensic methods now employed in the crime laboratory. Not all biological specimens will be suitable for DNA testing, or tests conducted may not provide a conclusive result. In these situations, classical serological tests will still be necessary to glean all possible probative information from the evidence materials. Because of the limited resources available for DNA testing, standard serology tests may be used to screen evidence samples to select the materials most likely to provide a successful DNA result. There will remain a need to identify, isolate, preserve, and analyze a wide range of evidence types, such as firearms, toolmarks, textile fibers, paint, and glass, as well as biological specimens to provide additional information to aid in crime reconstruction.

Care should be exercised by investigators in processing crime scenes to insure other evidence types are not overlooked in the hope of a definitive DNA test result. It is recommended that the local crime laboratory be consulted and kept involved in the evidence evaluation process throughout the investigation. These forensic specialists will insure other evidence types are appropriately analyzed and can assist in isolating materials for DNA testing, even though they may not now perform the test in their laboratories.

National implementation of DNA testing on evidence samples will require law enforcement agencies throughout the United States to commit additional resources for forensic services. Because of the complexity of DNA technology and the nature of the testing process, it is advisable that technical personnel be identified who can be dedicated to DNA testing. This will encourage a high level of technical proficiency and facilitate effective quality control procedures. Start-up costs for DNA testing include some specialized laboratory equipment, and in some instances, acquiring the necessary laboratory space to perform the tests. As testing gets underway, there will be additional costs for the chemical reagents used in the process and the DNA probe materials. Sources in the private sector have been identified who will provide these supplies, perhaps in the form of testing kits.

### Benefits

It is anticipated that the costs associated with the forensic application of DNA testing will be substantially offset by savings in investigative manhours required to develop evidence with which to sustain prosecutions. When this technology is fully implemented, it has the potential to identify perpetrators of crimes sooner in the investigative process and to clear suspects more readily so that investigative resources can be focused more productively. As the criminal justice system becomes better acquainted with the potential power of DNA technology, it is anticipated that additional savings in court time may be realized through shorter trials or averting trial altogether through an increased number of pleas.

### Summary

Advances in DNA technology represent perhaps one of the most significant forensic breakthroughs of the century in its ability to identify a rapist or murderer based on trace amounts of biological evidence left at the scene of a crime.

The goal of making DNA profiling a part of a crime laboratory's arsenal of scientific investigative techniques is being realized. A national commitment to the routine use of DNA technology by police agencies at all levels will result in a more efficient and effective law enforcement system.

**Footnotes**

[1]Joseph L. Peterson, et al, *Forensic Evidence and the Police: The Effects of Scientific Evidence on Criminal Investigations*, October 1984, U.S. Government Printing Office, publication 0-461-539/23742.

[2]A more-detailed description of the several DNA analysis techniques (written for the nonscientist) can be found in the *Crime Laboratory Digest*, 1988, vol. 15, supplement No. 1, entitled "A Primer on the Methods Used in the Typing of DNA." This publication is available through libraries or by requests directed to the FBI Laboratory, Washington, DC.