

Minnesota Department of Public Safety

Bureau of Criminal Apprehension Forensic Science Laboratory

Guide to DNA Analysis

Q. What is DNA?

DNA, which stands for deoxyribonucleic acid, is found in all nucleated cells in the body. With the exception of identical twins, each person's DNA is unique. DNA contains all the genetic information necessary to produce a human being. The figure below depicts the double helix ("twisted ladder") structure of DNA.

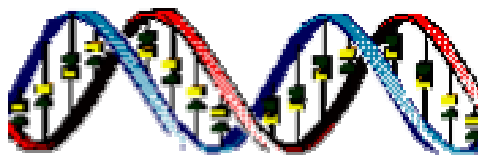


Figure 1. DNA Structure

Q. What is DNA testing?

DNA testing or "profiling" is a powerful scientific tool that is used to identify the source of biological evidence (blood, semen, etc.) by matching it with samples from a victim or suspect. For example, in a homicide, DNA from a blood sample on the suspect could be compared to DNA from a victim's blood sample. A match may assist in placing the suspect at the scene of the murder. In a rape case, the DNA profile of semen taken from a vaginal sample would be compared with the DNA profile of blood from a suspect. Since the profile of the suspect's semen will be the same as that of his blood, a match would strongly link the suspect to the crime.

Q. Why is DNA testing sometimes called DNA "fingerprinting"?

This name was given to DNA testing by the British scientist Dr. Alec Jeffries, whose pioneering work led to the development of a type of DNA testing known as restriction fragment length polymorphism (RFLP). He

chose the term "fingerprint" because DNA profile comparisons, like fingerprint comparisons, produce a unique pattern that can identify an individual. The terms DNA profiling or DNA typing are preferred.

Q. Which body fluids can be tested?

The key to DNA testing is the presence of cells containing DNA. Blood and semen are the body fluids that are most often tested. Saliva, vaginal fluid, hairs with follicular tissue at the root, soft bone (such as rib bones), and deep muscle tissue are also sources of DNA.

Q. When is it appropriate to use DNA testing?

DNA testing is appropriately used whenever such testing will materially aid in the investigation of a criminal case. Issues involving questions of identity can benefit greatly from DNA testing. Generally, cases that have an identified suspect are analyzed, however, as DNA data bases have grown it has become common to analyze cases with no known suspect. If the perpetrator has previously been compelled to submit a sample to the data base, s/he will be identified when the data base is searched.

Q. How should the samples be collected?

Body fluid stains are best preserved when kept cold and dry. All samples should be collected using appropriate collection procedures to minimize sample destruction and prevent the introduction of contaminants. Each item should be packaged separately. Liquid blood samples from victims and suspects should be collected in purple-top EDTA blood tubes (gray-top alcohol tubes are not acceptable); BCA evidence collection kits or equivalent materials should be used. It is also acceptable to collect a DNA sample using cheek swabs (buccal swabs); using a sterile cotton swab, gently swab the inside of the cheek. Cells that line the mouth will be collected on the swab. Allow this to air dry before packaging in a clean envelope. If possible, the blood/buccal controls from the victim(s), suspect(s), etc. should be submitted at the same time as the other evidentiary materials.

Q. Do contaminants at a crime scene affect DNA test results?

Evidence can be subjected to a variety of environmental hazards before being collected for analysis. Experience has shown that the vast majority of samples are unaffected by these contaminants, though some samples may show reduced DNA activity leading to no DNA profile, an incomplete profile, or inconclusive results. Contamination of evidence with human DNA can be a

potential problem, therefore, the evidence should be collected and packaged using procedures that prevent the inadvertent introduction of DNA from a contaminating source.

Q. What types of DNA testing are performed?

The first DNA testing technique that was used by the BCA Laboratory is known as "RFLP", which stands for Restriction Fragment Length Polymorphism's. In 2000, the BCA stopped using this procedure, which had been in use since 1990 for both casework and sex offender database samples. A newer DNA analysis technique known as the Polymerase Chain Reaction (PCR) has been used in casework at the BCA since 1993. PCR is a method in which millions of copies of specific genes within the DNA molecule can be made and typed within a relatively short period of time. Because of this "amplification" process, PCR works well with very small samples. Currently the BCA uses a form of the PCR technique known as the Short Tandem Repeat (STR) DNA method.

STRs are genetic markers that vary in size among individuals. Their overall small size makes them an excellent choice for use with PCR. Through a project coordinated by the FBI, 13 STR genes have been identified as the "core loci" to be used for casework and offender data basing. The use of 13 loci enables the power of discrimination of the STR tests to far exceed all other forms of DNA testing used to date, thus providing juries with information that would have been unimaginable only a few years ago.

Q. How long does it take to complete a DNA test?

DNA testing involves a series of steps. The overall time involved depends in part upon the number of samples that have to be tested. In general, PCR testing can be completed within two to three weeks after the case is started, however, current backlogs make this turn-around time as long as two months.

Q. How specific are DNA "matches"?

STRs are very discriminating for single-source samples. Typically, a complete DNA profile might be found in less than one in one hundred billion people. A typical DNA report would read "This profile would not be expected to occur more than once among unrelated individuals in the world population."



Figure 3: Examination and Collection

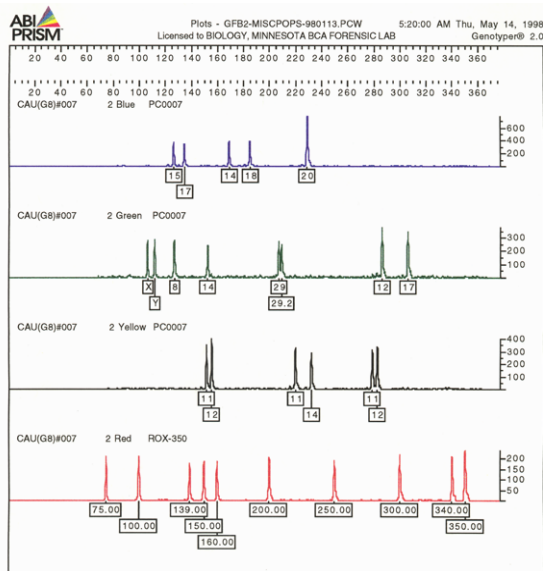


Figure 2. STR "Profiler Plus" Typing

Q. What can be done with mixtures of fluids from two or more people?

This situation is commonly encountered with sexual assault evidence. DNA extraction procedures are employed to separate sperm cell DNA from non-sperm cell DNA. In many cases this is successful and a clear profile of the perpetrator can be obtained. Sometimes complete separation cannot be obtained, and the rapist's sperm cell DNA will be mixed with DNA from the victim's cells. Blood-blood and semen-semen DNA mixtures can also occur. The ability to distinguish individual contributors to a mixed DNA profile will vary from case to case, and is highly dependent upon the relative quantity of DNA contributed to the mixture by each individual. A typical mixture report will read "The victim and the suspect are possible contributors to this mixture. It is estimated that 99.999% of the general

population can be excluded as being contributors to this mixture.”

Q. Are samples consumed in the process of DNA testing?

Yes. The amount of sample that is used depends upon the nature of the sample and the sample substrate. PCR testing can be performed on very small samples, however, sufficient sample must remain in order to allow independent testing should the defendant(s) choose to do so.

Q. Should cases without suspects be submitted?

Samples from violent crimes against persons should be submitted for analysis. The DNA from the evidentiary samples will be searched against the DNA profiles in the Combined DNA Index System (CODIS) database. The DNA profiles in this database come from evidentiary samples and convicted offenders. A missing persons database has also been developed. Samples from relatives of a missing person are analyzed and placed into the data base. If unidentified human remains are discovered, they can be analyzed and compared to the data base, thus allowing the identity to be determined.



Figure 4: STR DNA Analysis

Q. Can the DNA profiles be classified, stored, and searched by computer?

Yes. DNA profiles from evidence samples are routinely searched against the offender database as samples are added to each. These searches have resulted in hundreds of “cold hits” (identification of suspects based solely on the DNA profile obtained from evidence samples) nationwide. The BCA is linked to the National DNA Offender Database (called “CODIS”) that allows the BCA to search profiles against DNA offender databases maintained by many other states. Currently, all 50 states

have legislation allowing for collection of DNA samples from convicted offenders.

Q. How does the BCA collect DNA profiles of convicted offenders?

Minnesota Statute requires DNA profiling of all individuals (both adults and juveniles) convicted of any felony offense. The court shall order the individual to provide a blood/buccal sample to be forwarded to the BCA. If the court fails to order the collection of the sample, there is a separate responsibility imposed on the Commissioner of the Department of Corrections and/or the Local Corrections Authority to order the sample. The BCA Laboratory provides kits appropriate for the collection of offender samples.

Q. Who pays for the collection of samples from convicted offenders?

It is the responsibility of each jurisdiction to determine how they will pay for the cost of collecting these samples. Buccal swab collection can be performed by corrections personnel directly. With very little training, a proper sample can be collected and submitted to the BCA. All costs for the actual laboratory analysis are paid by the BCA.

Q. Are the results accepted in the courts?

Yes. The Minnesota Supreme Court has ruled DNA evidence admissible. STR test results have been used in numerous court cases. However, due to the remarkable power of DNA evidence and the inherent complexity of the testing procedure, legal challenges are sometimes encountered. The standards and practices of the BCA Laboratory Biology Unit are designed to withstand the most thorough court scrutiny and meet published standards for forensic DNA testing.

The **BCA Forensic Science Laboratory** is a Nationally Accredited full-service crime laboratory serving all Minnesota law enforcement agencies.

Laboratory services include: toxicology analysis (including blood and urine alcohol analysis), chemical testing (including drugs, arson, and explosives), biological analysis (including serology and DNA profiling), questioned document examination, trace evidence analysis, firearms and tool marks testing, latent fingerprint examination, and breath alcohol testing.

If you have any questions, please contact the BCA Forensic Science Laboratory at:

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