



Understanding Forensic DNA

DNA evidence can be a vital component of an investigation. As a victim of crime, the Commission will provide you any information you might need to understand the Commission's investigation and its findings. This resource is a guide to DNA evidence, DNA testing, and interpreting DNA test results. The Victim Services Coordinator is always available to answer any additional questions you might have.

What is DNA and where is it found?

DNA is the genetic blueprint of all living things. Every person has unique DNA, a signature uniquely reproduced in his or her cells. The only exception to this is identical siblings; identical siblings will have the same DNA.

When a crime scene is examined for DNA evidence, investigators will look for body fluids, such as blood, semen, urine, sweat, and saliva, as well as hair, and objects the perpetrator may have touched. Body fluid stains can provide a sample of cells, as will hair. As DNA testing technology has become more sensitive, small samples of skin cells can now also be analyzed. 'Touch DNA' or the DNA found in skin cells can be found on any object the perpetrator or victim touched. In a crime scene, DNA might be found on articles of clothing belonging to the victim or perpetrator, or on the victim's body. It can also be left on cigarette butts, drinking glasses, toothpicks, food, tissues, eyeglasses, and weapons, among other things.

What is a DNA profile?

A DNA profile is made of a set of specific points on a DNA molecule. Points of data, or loci, are examined to create a complete DNA profile, unique to the contributor. In the most common type of DNA testing, the profile is represented by a set of numbers and does not include any physical description of the contributor. Once the DNA profile is assembled, it can be compared to other DNA profiles to locate genetic matches or exclusions.

Some evidence may not produce a full DNA profile if the DNA is degraded, and there isn't information present at all loci. Some DNA evidence may be too degraded for any testing. Under some circumstances, a partial profile, or a profile that includes fewer than the full number of loci detected by a particular kit, can still be compared against a suspect's profile. A match using this method, however, will not provide the certainty that comparing two complete profiles would.

Types of DNA Testing

DNA is collected from the crime scene and possible contributors through a process called sampling. Sampling may take the form of swabbing a biological stain (i.e. blood stain, semen stain), scraping the fingernails of the victim, or collecting objects the perpetrator is suspected to have touched. Investigators may also use a special vacuum, an MVAC, to collect DNA from evidence. Suspects and victims will be asked to provide a DNA reference sample. The reference sample will then be compared to the DNA found in the crime scene sample(s).

DNA sampled from the crime scene is analyzed based on the quality and amount or quantity present. The most commonly used DNA test analyzes autosomal short tandem repeat (STR) DNA, DNA found in the nucleus, or center, of the cell that contains DNA inherited from both mother and father. This DNA is unique to the contributor except in cases of identical siblings. Other types of DNA tests include Y-STR and mtDNA. In cases in which there is a mixture of DNA present, and the major contributor is female (such as a sexual assault kit), Y-STR DNA may be analyzed. Y-STR DNA is only present in males and this testing will ignore the DNA from the female. Men who share the same paternal line (i.e. grandfather, father, brother) will have identical Y-STR profiles. Mitochondrial DNA (mtDNA) testing is used when DNA is badly degraded or the sample is of poor quality, such as hair samples with no root or bone fragments. Mitochondrial DNA is shared by the maternal line (i.e. grandmother, mother, aunt, uncle, brother, and sister will share the same mitochondrial DNA) and is found in the mitochondria of the cell, not the nucleus. Mitochondrial DNA testing is used most frequently in cases with a hair without a root present or when other DNA testing methods are not an option.

How are DNA test results reported?

The results of a comparison between a DNA sample found at the crime scene and a suspect's profile will be reported as either inclusion, exclusion, or inconclusive. Inclusion, or a match, means the suspect can be included as a contributor to the DNA sample found at the crime scene. Exclusion means the suspect is excluded as a contributor to the DNA sample found at the crime scene. Inconclusive means the DNA found at the crime scene is lacking in quality or quantity and cannot be compared to the suspect's profile. Statistics are also reported to reflect the strength of an inclusion or match.

Inconclusive results are common in post-conviction cases due to the age of the DNA collected, the degradation of

the DNA, and the extremely small amount of DNA newer testing kits detect. This can make it difficult for analysts to compare partial profiles developed from questioned items to an individual's standard.

Why do victims need to provide DNA samples?

Victims are often asked to provide "reference samples", a DNA sample used to exclude the victim's DNA from any DNA evidence found at the crime scene to help determine what came from a perpetrator. In sexual assault cases, individuals who have had consensual intercourse with the victim within four or five days prior to the crime will also need to provide reference samples.

A victim's DNA sample is only compared to the DNA evidence from that crime and is not uploaded to any databases.

What is CODIS and what information does it contain?

CODIS, or the Combined DNA Index System, is a national database that compiles DNA profiles identified by crime labs across the country. CODIS is managed by the FBI and contains two indexes: DNA profiles belonging to known offenders and DNA profiles found at crime scenes that have not yet been linked to a perpetrator. CODIS is a valuable tool for identifying serial offenders and linking known offenders to crime scenes, allowing investigators to access information across state lines.

When the profile of an unknown contributor (crime scene sample profile) is entered into CODIS, it is compared with both the profiles of known offenders and the profiles of unknown contributors (other crime scene profiles). If a match is located, the submitting agency will be notified. If no match is found, the profile will routinely be compared to all other profiles. CODIS only accepts certain profiles based on the sample category (for known offenders-profiles consisting of 20 loci, for crime scene evidence-profiles must contain certain loci and meet additional requirements). Depending on how partial the profile is, the profile may not be eligible for entry. Additionally, mixtures often do not meet the requirements to be uploaded to CODIS.

What are the limitations of DNA testing?

While DNA evidence is considered compelling and strong evidence, DNA alone cannot tell the complete story of a crime. Testing cannot tell investigators when or how DNA was left in a crime scene. In some cases, investigators will find an unknown profile on a weapon or other object collected from a crime scene. The presence of an unknown profile, however, does not mean the profile belongs to the 'true perpetrator.' The unknown profile could have been left at the crime scene before the crime occurred.

In older cases, particularly in cases before DNA testing was possible, evidence may not have been collected or stored in compliance with current rules meant to reduce the possibility of contamination and degradation. DNA from law enforcement, first responders, and other objects collected from the crime scene might be found when evidence is tested.

How does the Commission use DNA testing?

DNA evidence is one avenue, among many, the Commission explores during investigation. Each case requires individual evaluation to determine whether DNA testing should be pursued and to formulate a testing plan. The Commission's approach to DNA testing is informed by several factors: whether DNA testing was conducted during the initial investigation, the material objects collected during the investigation, and the number of people who may have interacted with the crime scene and evidence. Using this information, the Commission will determine what and who to test.

The Commission often investigates crimes that took place prior to significant advances in DNA testing technology. As DNA testing has evolved over the past two decades it has become increasingly more sensitive and can detect smaller amounts of DNA. Therefore, the Commission will test many items that have previously been tested for DNA evidence using older methods. The Commission will also evaluate all evidence collected during the initial investigation, such as clothing, bedsheets, and possible weapons, to determine whether they should be submitted for DNA testing. To ensure the DNA profiles of victims, consensual sexual partners, or residents of the household where the crime occurred are excluded from the DNA evidence found, the Commission will ask those who may have interacted with the crime scene and evidence to provide a reference sample. Depending on the circumstances of the case, the Commission may also seek court orders for alternate suspects who decline to provide voluntary standards.

Again, DNA evidence is only one piece of an investigation. DNA testing might return matches and exclusions, but in the vast majority of cases, neither a match nor an exclusion will alone prove guilt or innocence. When a reference sample returns a match to DNA evidence, investigators will seek to understand when and how the DNA was left at the crime scene. If the claimant is excluded as a possible contributor, the Commission does not conclude the claimant is innocent. Likewise, the Commission does not assume an unknown DNA profile belongs to the 'true perpetrator.' DNA evidence is a valuable tool for discovering who may have interacted with the crime scene, but interviewing eye witnesses, reviewing law enforcement's investigation, and other forensic analysis can provide the context to understand what the presence of the DNA means.

Glossary

When the Commission presents DNA evidence in a hearing, an expert on DNA analysis and testing will speak on the test results. This section provides an overview of the terms that may be used during the DNA expert's testimony.

- **STR DNA** – Short Tandem Repeat DNA. DNA found in the nucleus, or center, of the cell.
- **Y-STR DNA** – Nuclear DNA only found in males. All males in the same paternal lineage will have the same Y-STR DNA profile.
- **mtDNA** – mitochondrial DNA, or the DNA found in the mitochondria of the cell. Everyone in the same maternal lineage will have the same mtDNA profile. Mitochondrial DNA is often tested in bones, hairs without roots, and teeth.
- **Locus/Loci** – Specific locations on DNA molecules that are analyzed to create a DNA profile. “Locus” refers to one location on a DNA molecule and “loci” refers to multiple locations. A DNA profile must meet specific requirements to be eligible for entry into CODIS. The requirements depend on the specific category of the sample (reference vs evidence).
- **Alleles** – An individual's DNA characteristic at each locus. In STR testing there are two alleles at every locus; one inherited from the mother and one from the father.
- **Mixtures** – Refers to a mixture of DNA, which occurs when multiple people have deposited DNA on the same object. When there are more than two alleles at a locus, this means there is a mixture of DNA. Mixtures can be difficult to analyze, and analysts often require reference samples to differentiate between different profiles included in the mixture.
- **Allelic Dropout** – Occurs when DNA has degraded or when there is very little DNA, and all the alleles at specific loci cannot be analyzed.
- **Questioned Item** (also referred to as evidentiary item) – an item collected by law enforcement related to the crime.
- **Standard** – A DNA sample collected from an individual to compare to any DNA profiles developed from questioned items. There are two types of standards: elimination standards, which are collected from people known to have been at the crime scene (i.e. family members, roommates, first responders), and reference samples, which are collected from suspects and will be compared to the evidence DNA profiles. A standard is typically collected using a cheek swab, though a blood sample can also be used.
- **Sampling** – the process of collecting DNA from an item.
- **Quantitation** (Quant) – amount of DNA present in a sample. The lower the quant, the less likely an item is to produce a DNA profile.
- **“Stop at quant”** – no testing was conducted due to the limited amount of DNA present in the quant stage.
- **Degradation** – The process of DNA deteriorating or breaking down. DNA begins to degrade the moment it is deposited outside of its natural environment. The three main factors that most affect DNA degradation are heat, humidity, and direct sunlight.