RECENT DEVELOPMENTS IN THE USE OF DNA EVIDENCE
General Practice, Solo & Small Firm Section Program

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A PRIMER ON DNA EVIDENCE

With Emphasis on

ETHICAL AND PROFESSIONAL CONSIDERATIONS

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Brief History of Use of DNA Evidence

DNA was first used as evidence in the US court system in 1987. Today, DNA is routinely used in paternity, criminal, probate, personal injury, products liability, medical malpractice and immigration cases. DNA technology has become a useful tool for identifying or eliminating suspects in criminal cases when biological evidence such as saliva, tissue, blood, hair, or semen is found at a crime scene. DNA evidence now provides investigative leads and resolves issues of human identification, and has become the accepted standard in paternity and ancestry testing. DNA samples are now required in most immigration matters. DNA testing is becoming an important tool in the diagnosis and treatment of disease and injury.

If you intend to use (or contest) DNA evidence in a trial, you should be familiar with the legal origins of DNA evidence. A 1989 New York case, People v. Castro, was one of the first reported cases to discuss the issues concerning reliability and quality of forensic DNA testing, and to set standards for admissibility hearings that are broadly followed nationwide. The National Research Council (NRC) of the National Academy of Sciences published a report in 1992, “DNA Technology in Forensic Science,” that made several recommendations regarding analysis and interpretation of forensic DNA evidence. NRC is a great resource for the field of forensic DNA and can be accessed at http://www.nap.edu/books/0309045878/html. At the time of this 1992 report, the technology most commonly used for forensic DNA analysis was restriction fragment length polymorphism. The NRC concluded that RFLP methods were reliable, and laid the foundation for analysis and interpretation of DNA evidence.

As DNA technologies evolved beyond RFLP methods, there was some scientific criticism of the original report, and a need developed for more refined review and standards. The National Academy of Sciences convened another committee which reviewed the 1992 report and produced a second report: The Evaluation of Forensic DNA Evidence, published in 1996. This report produced further conclusions and recommendations regarding laboratory and statistical interpretation of DNA evidence, and may be accessed at http://www.nap.edu/books/0309053951/html/index.html. If you intend to successfully utilize DNA evidence (or if you intend to successfully cross-examine in this area), you should familiarize yourself with these reports in order to gain a basic understanding of DNA evidence.

The evolution of DNA as evidence has produced strict standards for the entire process of DNA collection, analysis, testing, and admissibility. The scientific basis of DNA science has been found to be reliable and admissible, and is no longer challenged. While you have the right to challenge the science behind DNA, and you may attempt to convince a court not to accept DNA evidence, your efforts will likely not be successful. It is much better practice to focus on the collection and analysis process, contamination, quality assurance, and Fourth Amendment protections, rather than trying to claim that DNA is not reliable enough to be admissible. You will need to employ an expert, who can guide you regarding the collection and analysis as well as the interpretation of the DNA test results. As with most areas upon which experts testify, there can be legitimate disagreement over the meaning of DNA test results in a given case.

What is DNA?

You have heard that DNA constitutes the building blocks of life. All living organisms are made up of cells, and all cells (except red blood cells) contain genetic material known as deoxyribonucleic acid (DNA). DNA is known as a genetic blueprint. It contains the directions that determine an individual’s genetic characteristics. A person’s DNA is the same in blood, saliva, semen, fingernails, and all other biological material. It may be in such small samples that it is not visible to the human eye. Potential sources of DNA are as widely varied as teeth, bones, bottles and
cans, gloves and clothing, earrings, combs, eyeglasses, bite marks, condoms, toothbrushes, gum, stamps, tissues, sweatbands, and cigarette butts.

**Rules of DNA**

The four-letter DNA alphabet of C, G, T, and A always follows certain rules. Bases can only pair together in a specific way: C only bonds to G, and T only bonds to A (“C-G G-C T-A A-T”).

**Base Pairing**

The specific combination of these bases through chemical bonds is known as ‘base pairing.’ All of the DNA in a cell is known as the genome. The human genome has approximately 3 billion base pairs. Because there can be trillions of base-pair combinations, scientists can reliably report on DNA analyses. It is the specific order (sequence) of these base pair combinations that determines each person's genetic individuality.

**Polymorphism**

99.9% of all DNA is the same among humans. Scientists use a small portion of the remaining 0.1% for DNA testing because of its high variability among people. This variability is called polymorphism.

**STRs (Short Tandem Repeats)**

While the history of forensic DNA human identity testing dates back to 1985, the most widely used DNA markers are defined by their 'Short Tandem Repeat' (STRs) characteristics on the chromosome. Multiple types of STRs can be analyzed in one test, or multiplexed, thus making the analysis process faster than previous technologies. Multiplexed STRs are very valuable because they can produce results that are highly reliable for identification, even with old or minute biological samples.

**Forensic DNA Profile**

A forensic DNA profile is the combination of individual genotypes for all of the DNA markers or loci that have been analyzed. For forensic identity testing, a DNA profile is compared to other DNA profiles from biological samples such as crime scene evidence or samples from known individuals.

**Collection**

If you are reviewing DNA evidence collected by the prosecution, you should be aware of the following procedures which law enforcement must utilize in the process:

**Securing the Scene**

The scene boundaries are established by identifying the focal point of the scene and extending outward. Any type of physical barrier can be used to section off the area. A log of all persons who had access to the scene should be maintained. This will provide important information for evaluating the need for elimination samples from those persons.

**Documentation**

Crime scene documentation is an important resource for the evaluation of the integrity and condition of the evidence. Crime scene documentation is essential to establish the location, condition
and chain of custody for each item collected. Common documentation methods can include:

- Notes
- Diagrams
- Photographs
- Video and audio

Collection

Biological material can be collected by taking the whole item, such as a pair of blue jeans or a weapon, or by taking a representative sample of the item. A representative sample can be obtained by lifting, cutting, swabbing, or scraping. Liquid samples can be collected by soaking up the sample with cotton-tipped swabs or gauze patches or through the use of a pipette.

Contamination

Contamination of DNA from one source can occur when it comes into contact with DNA from another source. Contamination can occur during collection, such as handling the evidence without wearing gloves, failing to change gloves between collecting samples, or packaging two or more items in the same collection container. Contamination may occur in the laboratory, such as when equipment is not properly cleaned before an item is examined.

Degradation Factors

Factors that promote DNA degradation include:

- UV rays (prolonged exposure).
- Heat, humidity, and moisture
- Bacteria and fungi (often found in foliage and soil)
- Acids or chemical cleaning solutions (such as bleach)

Transportation/Storage

Extended exposure to heat or humidity causes degradation of biological evidence. To reduce this threat, the packaged items from the crime scene should be moved to a suitable storage facility as soon as possible.

**PRACTICE NOTE:** It is essential to review each of the above areas if you intend to effectively cross-examine. It is equally essential for you to consult with an accredited forensic expert for their review of the above areas. Failure to do so may be grounds for an ineffective assistance of counsel claim.

Analysis

Comparing Genetic Profiles

Forensic DNA analysts compare the genetic profile obtained from crime scene evidence to the profile from a known individual (e.g., suspect, victim). If the DNA profiles from the evidentiary and known samples are the same at each locus, laboratory analysts can provide a determination of the statistical significance of the evidence. In some cases, no conclusive interpretation can be made.
Statistical Interpretation of the Evidence

Typically there are three possible laboratory outcomes:

1. If the DNA profiles from the evidentiary and known samples are consistent at each locus, laboratory analysts can interpret this finding as a "match," "inclusion," or "failure to exclude."
2. If the two profiles are not consistent at each locus, the finding can be interpreted as a "nonmatch" or "exclusion."
3. If there are insufficient data to support a conclusion, the finding is often referred to as "inconclusive."

PRACTICE NOTE: Depending on the reported outcome, this may be a rich area for cross-examination. Consultation with an accredited expert is essential to help you with the interpretation of the results and the ensuing cross-exam. This is an area where you may win the case, or you may potentially be sued. As always, do your homework well in advance, and be properly prepared.

Statistical Interpretation of the Match

Generally, once a DNA match is determined, a statistical computation is performed to estimate how often a random unrelated person would be found with that particular DNA profile. Once an individual's profile is identified, it is statistically improbable that anyone else in the world will have the same profile, unless that person has an identical twin. Identical twins (twins derived from a single fertilized egg) have identical STR DNA profiles.

Probability of Exclusion

Conclusions using this statistic relate the probability that a random person from the reference population would potentially be excluded from contributing to the mixture. For example, the probability of excluding a random person from the U.S. population from contributing to the DNA mixture is estimated to be greater than 99.997%.

CODIS

In 1990, the Federal Bureau of Investigation (FBI) Laboratory began a pilot project called the Combined DNA Index System (CODIS) creating software that enables Federal, State, and local laboratories to exchange and compare DNA profiles electronically.

CODIS Systems

The CODIS system operates on three levels:
1. National DNA Index System (NDIS)
2. State DNA Index System (SDIS)
3. Local DNA Index System (LDIS)

State Statues and DNA Databasing

Many states are enacting statutes that require the collection of DNA samples from all convicted persons, and in some cases, all arrested persons. The nationwide criminal DNA database
is expanding rapidly as a result of these statutes.

**How Is a Suspect's DNA Obtained?**
- Secured from an arrestee or a convicted person under a law requiring such persons to provide DNA samples
- Seized during a suspect's arrest or detention
- By court order, such as a search warrant or grand jury subpoena
- By consent or from a sample left in a public place or crime scene.

**Constitutional Considerations**
As a general rule, when evidence is obtained in a criminal investigation or proceeding, several constitutional rights might be involved:
- The Fourth Amendment protection against unreasonable searches and seizures
- The Fifth Amendment privilege against compelled self-incrimination
- The Sixth Amendment right to counsel
- The guarantee of due process of law

In most instances, there will be no Fifth or Sixth amendment issue.

**Self-Incrimination and the Right to Counsel**
DNA, like a fingerprint, a blood sample, or hair, is nontestimonial evidence. Thus, there is no violation of the Fifth Amendment privilege against compelled self-incrimination when DNA evidence is lawfully seized. The main issues, therefore, are whether there is a lawful seizure of the individual or the DNA evidence, whether any consent to search is lawful, and whether the means of obtaining the DNA evidence comply with due process principles.

**Retaining DNA Samples**
When DNA evidence has been lawfully obtained, there is no limitation placed on future examination of the evidence in connection with any other crime. In this regard, DNA evidence is no different than a lawfully collected fingerprint.

When DNA evidence is obtained by consent, the lawfulness of its future use may be determined by the language used to obtain consent. Future use of a consensual sample will be prohibited if the subject was informed that the DNA sample was to be taken for one comparison involving a specific crime.

**DNA Dragnets**
The use of a dragnet for temporary seizure of a large number of individuals to gather DNA evidence is forbidden. The law requires individualized suspicion before a person may be detained and individualized probable cause before an individual may be arrested.

However, there is no constitutional prohibition on requesting DNA samples from large numbers of people who are not detained or arrested, provided the consent is obtained voluntarily.

**"Cold Hits" and Probable Cause**
When DNA evidence is recovered from a crime scene, time may pass, even years, before comparison with a known DNA sample identifies the source of the DNA evidence. This is known as a cold hit. Cold hits are database matches that identify someone who was not previously suspected. The DNA match establishes probable cause for an arrest.
Basic Discovery of Forensic DNA Evidence

Discovery issues involve two related matters: the duty to preserve evidence and the duty to disclose. Each duty can be defined by the law of the jurisdiction and constitutional mandate. A secondary issue involves the timing of disclosure: when is it mandated, and when is it beneficial to the parties and the court.

Search and Seizure Issues

DNA (or bodily fluids containing DNA) may be seized by court order, or as a result of an arrest. Neither the right to privacy nor the privilege against self-incrimination prevents the seizure of DNA. Genetic material left at a place where there is no expectation of privacy may be seized. Refusing to cooperate in a court-ordered DNA test may be admissible as evidence against the defendant at the time of trial (or at sentencing). A court may order forcible collection of biological material for DNA testing if the defendant refuses to cooperate. There is no automatic right to demand that other persons be tested. A court order based on a showing of good cause is necessary before such a test may be required.

The defendant may seek access to the following information:

- An explanation of DNA testing and interpretation of results
- An assessment of the accuracy of the prosecution lab's conclusion in the case
- The significance of that conclusion in terms of the overall evidence in the case
- A defense expert to evaluate the residual portion of the evidence at his/her own expense
- An independent laboratory to conduct DNA testing if consumption is an issue

Post-trial Consequences of DNA Testing

Defense counsel should be aware of the following consequences:

- Except in cases in which DNA is obtained by limited consent, or if database law restrictions apply, DNA lawfully obtained by police may be used in future investigations and/or to examine past crimes.
- If the defendant elects to plead guilty (or is convicted), he or she may be compelled to provide DNA to a database, and that DNA sample is thereafter available for future investigations and/or to examine past crimes.
- If the defendant is not convicted of a qualifying crime, he or she may be entitled to have DNA samples or test results expunged.

PRACTICE NOTE: Make sure you properly advise your client of the consequences of a conviction, a plea, or an acquittal.

The failure to seek expert assistance, even on a consultancy basis, may deprive the defendant of the constitutional guarantee of the effective assistance of counsel. This determination must be made on a case-by-case basis.

Finding a Qualified Expert and Laboratory – Is It Your Legal Duty?

Locating a qualified forensic or DNA expert can be critical to the success of your case, and is no different than finding the right expert witness for any type of case. Obtaining the expert, and obtaining a competent one is very likely your duty under the Texas Disciplinary Rules of Conduct. To review, the TDRC require you to zealously represent your client and assert his/her position. The TDRC require you to be competent, prompt and diligent. Specifically, TDRC Rule 1.01(a) requires
you to possess the legal knowledge, skill, and training reasonably necessary for the case, and requires you to act with competence, commitment and dedication to the interest of the client and with zeal in advocacy upon the client’s behalf.

If you are unfamiliar with the forensic and DNA world, how do you go about finding the expert? The internet is a rich source of information, and is a great starting point. Careful review of qualifications, publication history, and trial experience is a must. Don’t forget to look at the results of the trials in which the expert participated, and who the opposing expert was. If possible, review transcripts and talk to the attorneys involved. A paternity testing laboratory should have an AABB (American Association of Blood Banks) certification. Other certifications to check for are American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB); Forensic Quality Services (FQS); College of American Pathologists (CAP) Laboratory Accreditation Program; Clinical Laboratory Improvement Amendments (CLIA); and International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025.

As you check your expert’s employment history, check the accreditations of the laboratories or institutions where he/she has worked. Ask the expert if he/she participated in the accreditation process, or if he/she has been asked to be an auditor or inspector for any of the accrediting bodies.

The Future of DNA Evidence

As DNA technology advances, it will soon be possible to accurately predict the physical appearance of a suspect, as well as biogeographical ancestry and approximate age determination. There are also rapid developments in genetic predisposition for disease. The legal ramifications of this burgeoning area are the subject of an entirely separate presentation.

There are also lawsuits springing up around the country against the pharmaceutical industry for not providing proper dosing and warnings on certain medications. Drug-specific genetic tests are becoming available that can guide the physician in adjusting dosages or switching medications for patients who are poor-to-intermediate metabolizers of the medication.

NOTE: This presentation is a summary of information from numerous sources, primarily “Principles of Forensic DNA for Officers of the Court,” a publication of the National Institute for Justice.
GLOSSARY OF TERMS

The following glossary of basic DNA terminology is included courtesy of the National Institute of Justice “Principles of Forensic DNA for Officers of the Court.”

ABO blood typing - A commonly used genetic typing test that uses antibodies to detect variations on the surface of human red blood cells. Individuals are typed as having A, B, O, or AB type blood by testing liquid or stains from body fluids (e.g., blood, saliva, vaginal secretions). One out of every three randomly selected pairs of people has the same ABO blood type.

Allele - A different form of a gene at a particular locus. The characteristics of a single copy of a specific gene, or of a single copy of a specific location on a chromosome. For example, one copy of a specific STR region might have 10 repeats, while the other copy might have 11 repeats. These would represent two alleles of that STR region.

Allele Frequencies - Term used to characterize genetic variation of a species population.

Allelic dropout - Failure to detect an allele within a sample or failure to amplify an allele during PCR.

Alternate light source (ALS) - Equipment used to produce visible and invisible light at various wavelengths to enhance or visualize items of evidence (fluids, fingerprints, clothing fibers, etc.). The light will cause possible biological stains to change color or fluoresce, assisting in the location process.

Amelogenin - A gene present on the X and Y sex chromosomes that is used in DNA identification testing to determine the gender of the donor of the DNA in a biological sample.

Amplification - Producing multiple copies of a chosen DNA region, usually by PCR (Polymerase Chain Reaction).

Autosomal - Chromosomes which are not sex chromosomes.

Base pairing - A, T, C, and G are molecular building blocks of DNA that only continue in specific "base" pairs, e.g., A only pairs with T, and C only pairs with G.

Bases - The four building blocks of DNA are called bases. The building blocks are Cytosine, Guanine, Thymine, Adenine and are commonly referred to as C, G, T, A.

Bench notes - A laboratory analyst's recorded notes.

Biallelic - Pertaining to both alleles, e.g. single nucleotide polymorphisms display two alternate forms and are biallelic.

Blind testing - In a blind test, analysts do not know they are being tested. In most forensic DNA laboratories, blind tests are not used.

In practice, it is almost impossible to design and implement an effective blind proficiency testing program in forensic science. Most attempts have failed because they could not produce an effective case scenario with realistic representation of the pre-laboratory
steps. Others failed because the analyst recognized that the supposed "evidence" was a manufactured artifact. Overall, it has proven impossible to realize the theoretical extra benefits of blind testing, and resources have been devoted to promoting better quality external open tests.

Cambridge Reference Sequence (CRS) - A "master template" of the HVR-1 region of mitochondrial DNA.

Capillary Electrophoresis (CE) - The platform for CE uses narrow silica capillaries (or tubes) containing a polymer solution through which the negatively charged DNA molecules migrate under the influence of a high voltage electric field. Important advantages of the CE technique, compared to slab gel electrophoresis, include quicker and more easily automated analyses.

Chain of custody - A record of individuals who have had physical possession of the evidence and the process used to maintain and document the chronological history of the evidence. (Documents can include, but are not limited to, name or initials of the individual collecting the evidence, each person or entity subsequently having physical possession of it, dates the items were collected or transferred, where the item(s) were collected from, agency and case number, victim's or suspect's name (if known), and a brief description of the item.

Chromosome - A physical structure in the cell nucleus. It consists of a tightly coiled thread of DNA with associated proteins and RNA. The genes are arranged in linear order along the DNA.

CODIS - Combined DNA Index System. A collection of databases of DNA profiles obtained from evidence samples from unsolved crimes and from known individuals convicted of particular crimes. Contributions to this database are made through State crime laboratories and the data are maintained by the FBI.

13 CODIS core loci - Thirteen STR (short tandem repeat) sequences that have been selected for the Combined DNA Index System (CODIS).

Cold hit - When CODIS recognizes a match between an offender and forensic profile, it is referred to as a "cold hit".

Competency - The combination of demonstrated knowledge, skills and abilities.

Contamination - The unwanted transfer of material from another source to a piece of physical evidence.

Cytoplasm - The viscid, semifluid matter contained within the plasma membrane of a cell, excluding the nucleus.

Degradation - the fragmenting or breakdown of DNA by chemical or physical means.

DNA (deoxyribonucleic acid) - Often referred to as the "blueprint of life," DNA is the genetic material present in the nucleus of cells that is inherited half from each biological parent.

Dideoxy sequencing - Dideoxynucleotide sequencing, also known as the 'Sanger method,' is a technique that uses dideoxyribose instead of deoxyribose to stop the synthesis of a
complementary DNA strand at various points when sequencing.

Differential extraction - A procedure in which sperm cells are separated, or extracted, from all other cells in a sample.

DNA fingerprinting - Analyses of the lengths of the fragments reveal that when looking at multiple VNTRs within and between individuals, no two people have the same assortment of lengths. This technique became known to the public as "DNA fingerprinting" because of its powerful ability to discriminate between unrelated individuals.

DNA mixtures - A sample that contains the DNA of more than one individual.

DNA profile - For an individual, the DNA types present at a particular set of tested DNA regions.

Electropherogram - A representation of alleles in the form of peaks after separation by electrophoresis and electronic detection.

Electrophoresis - To separate molecules on the basis of electric charge, size, or other physical properties.

Elimination sample - An elimination sample is one of known source taken from a person who had lawful access to the scene (e.g., fingerprints from occupants, tire tread impressions from police vehicles, footwear impressions from emergency medical personnel) to be used for comparison with evidence of the same type.

Evidentiary samples - A generic term used to describe physical material/evidence discovered at crime scenes that may be compared with samples from persons, tools, and physical locations.

Exclusion - The elimination of an individual as the source of a biological sample. This occurs when one or more types from a specific location in the DNA of a known individual are not present in the type(s) for that specific location in the DNA obtained from an evidence sample.

Exogenous DNA - DNA originating outside an organism that has been introduced into the organism.

External testing - An external test is one that is created and administered by an outside agency.

Forensic Index - DNA profiles developed from crime scene evidence and uploaded into CODIS are maintained in the forensic index of the database.

Forensic unknowns - DNA profiles obtained from crime scene evidence samples that are unmatched to a known individual.

Fractions - The result of the differential extraction; separating sperm cells from all other DNA material.

Gene - The basic unit of heredity; a functional sequence of DNA in a chromosome.
Genome - All the genetic material in the chromosomes of a particular organism; its size is generally given as its total number of base pairs.

Genotype - The genetic constitution of an organism, as distinguished from its physical appearance (its phenotype). The designation of two alleles at a particular locus is a genotype.

Haplotyp - A way of denoting the collective genotype of a number of closely linked loci on a chromosome.

Heteroplasmy - The presence of more than one mtDNA type within a single individual.

Heterozygous - If two alleles are different at one locus, the person is heterozygous at that genetic location.

HIPAA - Health Insurance Portability and Accountability Act of 1996.

HLA DQ-alpha - A polymorphic gene in the Human Leukocyte Antigen (HLA) region of chromosome 6 that has been well studied and analyzed for many purposes, including paternity testing, transplantation biology, and human DNA identification testing.

Homzygous - If two alleles at a locus that are indistinguishable, the person is homozygous at that genetic location.

Hybridization - The process of joining two complementary strands of DNA to form a double-stranded molecule.

Hypervariable - An area on the DNA which can have many different alleles in differing sequences.

Inclusion (failure to exclude) - The inability to exclude an individual as a possible source of a biological sample. This occurs when all types from a specific location in the DNA of a known individual are also present in the types for that specific location in the DNA obtained from an evidence sample.

Inconclusive - A situation in which no conclusion can be reached regarding testing done due to one of many possible reasons (e.g., no results obtained, uninterpretable results obtained, no exemplar/standard available for testing).

Internal testing - An internal test is one that is created and administered by the laboratory itself.

Intimate sample - An intimate sample generally refers to a biological sample obtained from a source other than the mouth (saliva) and head (hair).

"Junk" DNA - Areas of DNA that do not have an identified purpose, or do not code for genes.

Known samples - A DNA sample for which the source is known. These samples are generally obtained from the victim and/or suspected perpetrator of a crime, as well as from other persons whose DNA might be reflected when samples of the evidence are analyzed (could include a boyfriend, husband, or other third-party). These samples are
also referred to as reference samples, since they serve as a reference to which the unknown DNA samples are compared with the goal of identifying the source of the unknown DNA samples.

LDIS - The Local DNA Index System of CODIS which uploads forensic and offender DNA profiles to the State DNA Index System, or SDIS.

Length heteroplasmy - The presence of mtDNA molecules that differ in length.

Likelihood ratio - The ratio of two probabilities of the same event under different hypotheses. In DNA testing often expressed as the ratio between the likelihood that a given profile came from a particular individual and the likelihood that it came from a random unrelated person. Note that in this case the likelihood of each event does not add to give 1 (100% likelihood) as it does not incorporate the possibility of error or that the profiles came from twins or other near relatives.

Locus (pl. loci) - The specific physical location of a gene on a chromosome.

Match - Genetic profiles are said to 'match' when they have the same allele designations at every loci.

Mitochondrial DNA (mtDNA) - The DNA found in the many mitochondria found in each cell of a body. The sequencing of mitochondrial DNA can link individuals descended from a common female ancestor.

Multiplex - A system for analyzing several loci at once. National DNA Index System (NDIS) - Authorized by the DNA Identification Act of 1994, the FBI administers this national index. NDIS compares DNA profiles associated with a crime scene to DNA profiles collected from known convicted offenders, as well as to other crime scene profiles. When the DNA profiles are uploaded to NDIS, they are searched against the other DNA profiles submitted by other participating states.

No results - A situation in which no interpretable results are obtained from testing a DNA sample. A finding of no results can be due to the absence of DNA, insufficient DNA, or substances that inhibit the PCR process, among other reasons.

Non-conformances - Inconsistencies in laboratory practices that do not meet accreditation standards.

Nonmatch - An individual is eliminated as the source of a biological sample. This occurs when one or more types from a specific location in the DNA of a known individual are not present in the type(s) for that specific location in the DNA obtained from an evidence sample.

Nuclear DNA - The DNA found in the nucleus of a cell.

Nucleated - Having a nucleus or occurring in the nucleus.

Nucleus - The cellular organelle that contains most of the genetic material.

Objective test - A test which having been documented and validated is under control so that it can be demonstrated that all appropriately trained staff will obtain the same results
within defined limits. These defined limits relate to expressions of degrees of probability as well as numerical values.

**Offender Index** - DNA profiles developed from qualifying offenders and uploaded into CODIS are maintained in the offender index of the database.

Partial profile - DNA evidence that does not yield identifiable results in all 13 core loci.

Partially degraded DNA - Forensic DNA evidence exposed to environmental conditions that may prevent it from yielding a usable profile.

PCR inhibitors - A substance that interferes with the Polymerase Chain Reaction (PCR) process. Examples of PCR inhibitors include dyes, soil, chemicals, and heme (hemoglobin).

Polymerase Chain Reaction (PCR) - A process used in DNA identification testing in which one or more specific small regions of the DNA are copied using a DNA polymerase enzyme so that a sufficient amount of DNA is generated for analysis.

Polymorphic - Variable, more than one kind.

Polymorphism - Variations in DNA sequences in a population that are detected in human DNA identification testing.

PopStats - FBI CODIS software program used to perform statistical DNA match estimates.

Probability - The chance of observing a particular future event; a simple ratio of the number of observed events divided by the total number of possible events.

Probability calculations - Predictions based on small sampling of a larger population.

Probability of exclusion - The probability that a random individual would be excluded as the source of analyzed DNA evidence.

Probability of inclusion - The probability that a random individual would be included as a potential source of analyzed DNA evidence.

Product rule - The product rule calculates the expected chance of finding a given STR profile within a population by multiplying the frequency of occurrence of the combination of alleles (genotype) found at a single locus, by the frequency of occurrence of the genotype found at the second locus, by the frequency of occurrence, in turn, of each of the other genotypes at the remaining STR loci.

Proficiency testing - A DNA proficiency test uses biological samples to assess a lab analyst's ongoing competency and the laboratory's ability to produce accurate results.

Quality Assurance (QA) - A program conducted by a laboratory to ensure accuracy and reliability of tests performed.

Quantitation - Method used to determine the quantity of "x" in a given sample. In this context, it refers to the quantity of DNA in a sample and is usually reported as ng/µl.

Random match probability - The probability that the DNA in a random sample from the population has the same profile as the DNA in the evidence sample.

Reference sample - A standard/reference sample is material of a verifiable/documenting source which, when compared with evidence of an unknown source, shows an association
or linkage between an offender, crime scene, and/or victim (e.g., a carpet cutting taken from a location suspected as the point of transfer for comparison with the fibers recovered from the suspect's shoes, a sample of paint removed from a suspect vehicle to be compared with paint found on a victim's vehicle following an accident, or a sample of the suspect's and/or victim's blood submitted for comparison with a bloodstained shirt recovered as evidence).

Restriction fragment length polymorphism (RFLP) - Variation in the length of a stretch of DNA.

SDIS - State DNA Index System containing the state-level DNA records uploaded from local laboratory sites within the state. SDIS is the state's repository of DNA identification records and is under the control of state authorities. The SDIS laboratory serves as the central point of contact for access to NDIS. The DNA Analysis Unit I (DNAUI) serves as the SDIS laboratory for the FBI.

Sequence (or site) heteroplasmy - the presence of mtDNA molecules that have different nucleotides at the same address.

Short Tandem Repeats (STR) - Small regions of the DNA that contain short segments (usually 2, 3, 4, or 5 bases long), repeated several times in tandem (side-by-side).

Single Nucleotide Polymorphisms (SNPs) - DNA sequence variations that occur at single nucleotide (A,T,C, or G).

Standard Operation Procedures (SOP) - A prescribed procedure to be followed routinely.

Stochastic effects - Being or having a random variable.

STR typing - DNA analysis method which targets regions on the chromosome which contain multiple copies of an identical DNA sequence in succession.

Substrate - Any background material upon which biological sample has been deposited (e.g., clothing, glass, wood, upholstery).

Threshold value - A relative fluorescent unit (RFU) value that must be exceeded to make an allele call. This value will vary among laboratories.

Uninterpretable - Results that might be reported by the laboratory when alleles cannot be interpreted.

UV light source - Use of an ultraviolet light source to enhance or visualize potential items of evidence (fluids, fingerprints, clothing fibers, etc.). The light will cause possible biological stains to change color or fluoresce, assisting in the location process.

Validation - The process of extensive and rigorous evaluation of DNA methods before acceptance for routine use.

Variable Number of Tandem Repeats (VNTRs) - Repeating units of a DNA sequence; a class of RFLPs.

Variant - A dissimilarity in the commonly occurring sequence of a gene.