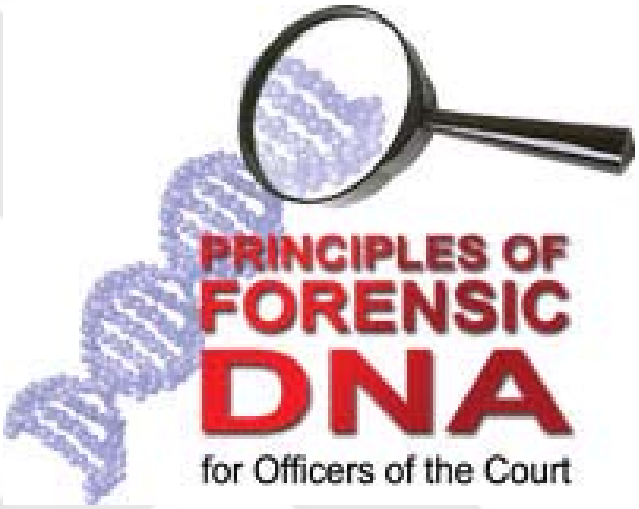
Forensic DNA for Officers of the Court

This course is provided free of charge and is part of a series designed to teach about DNA and forensic DNA use and analysis.

Find this course live, online at:
http://dna.gov/training/otc/

Updated: March 16, 2009



DNA INITIATIVE

www.DNA.gov

About this Course

This PDF file has been created from the free, self-paced online course "Forensic DNA for Officers of the Court." To learn more and take this and other courses online, go to http://www.dna.gov/training/online-training/. Most courses are free but you must first register at http://register.dna.gov.

If you already are registered for any course on DNA.gov, you may login directly at the course URL, e.g., http://letraining.dna.gov or you can reach the courses by using the URL http://www.dna.gov/training and selecting the "Login and view your courses" link.

Questions? If you have any questions about this file or any of the courses or content on DNA.gov, visit us online at http://www.dna.gov/more/contactus/.

Links in this File

Most courses from DNA.Gov contain animations, videos, downloadable documents and/or links to other useful Web sites. If you are using a printed, paper version of this course, you will not have access to those features. If you are viewing the course as a PDF file online, you may be able to use some of these features if you are connected to the Internet.

Animations, Audio and Video. Throughout this course, there may be links to animation, audio or video files. To listen to or view these files, you need to be connected to the Internet and have the requisite plug-in applications installed on your computer.

Links to other Web Sites. To listen to or view any animation, audio or video files, you need to be connected to the Internet and have the requisite plug-in applications installed on your computer.

Legal Policies and Disclaimers
See Legal Policies and Disclaimers for information on Links to Other Web Sites, Copyright Status and Citation and Disclaimer of Liability and Endorsement.

Principles of Forensic DNA for Officers of the Court

Opinions or points of view expressed in this training represent a consensus of the authors and do not necessarily reflect the official position or policies of the U.S. Department of Justice.

Introduction

Principles of Forensic DNA for Officers of the Court is an interactive resource to educate and assist prosecutors, defense attorneys, and judges in forensic DNA cases.

- DNA Evidence Overview
- Program Objectives

DNA Evidence Overview

DNA was first introduced as evidence in the United States court system in 1987. DNA technology has become an increasingly powerful forensic tool for identifying or eliminating individuals as perpetrators of a crime when biological evidence such as saliva, tissue, blood, hair, or semen is left at a crime scene. Outside the courtroom, DNA can provide important investigative leads to resolve issues of human identification.

DNA Admissibility

Since its introduction, forensic DNA testing has had a profound effect on our Nation's judicial system. In 1989, *People* v. *Castro* raised important issues concerning reliability and quality of forensic DNA testing and the case prompted the first of many admissibility hearings across the Nation.

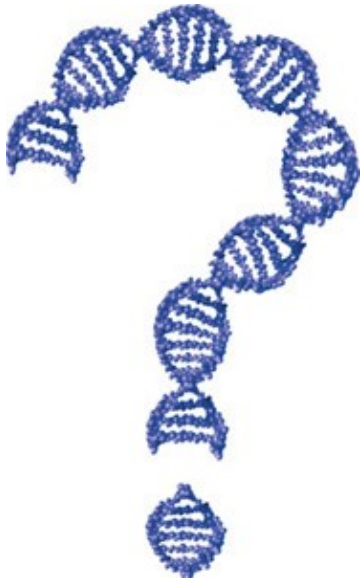
Click here for more information on the Castro case.

Admissibility Issues

Rigorous challenges have resulted in standards for the process of DNA analysis and the admissibility of DNA evidence. Rather than refuting the scientific basis for DNA analysis, lawyers and judges now find themselves in admissibility hearings delving into issues such as contamination, quality assurance, and Fourth Amendment

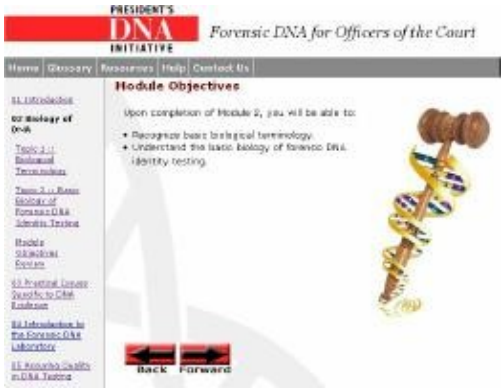
protections.

Interpretation



Even if DNA evidence is admitted, there still may be disagreement about its interpretation - what do the DNA results *mean* in a particular case?

An Interactive Resource



This interactive training tool is designed to assist prosecutors, defense attorneys, and judges in cases in which forensic DNA is an issue.

DNA Terms and Issues

This program defines DNA terms and technologies used in forensic applications. It also addresses scientific, evidentiary, and other legal issues that arise as a result of expanded uses of DNA evidence and DNA databanks.

Program Objectives

Upon completion of this program, you will be able to —

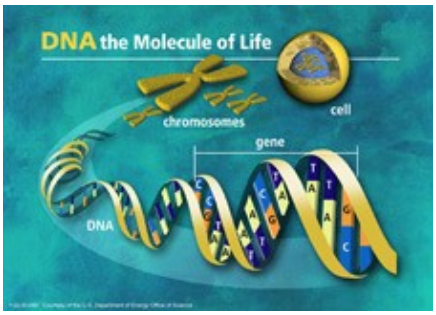
- Understand terminology associated with forensic DNA technologies.
- Identify technical issues associated with DNA analysis.
- Interpret DNA reports.
- Assist victims, defendants, jurors, and others in understanding DNA analysis.
- Identify and resolve legal issues that arise in the course of adjudicating cases involving DNA analysis whether before or after conviction.

Module Objectives

Upon completion of Module 2, you will be able to:

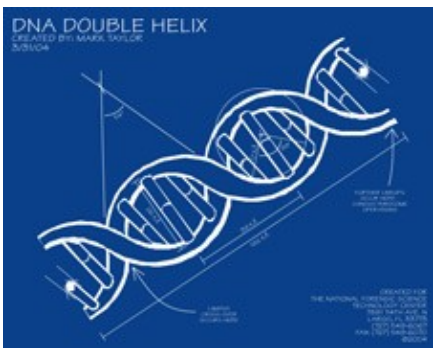
- Recognize basic biological terminology.
- Understand the basic biology of forensic DNA identity testing.

Biological Terminology



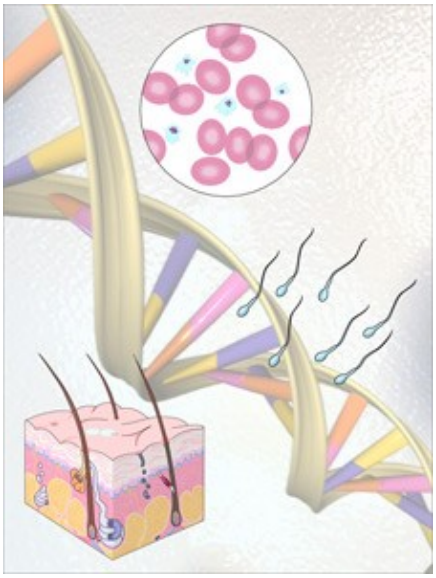
All organisms are made up of cells. The average human has approximately 100 trillion cells. All cells except red blood cells contain genetic material known as deoxyribonucleic acid (DNA).

What is DNA?



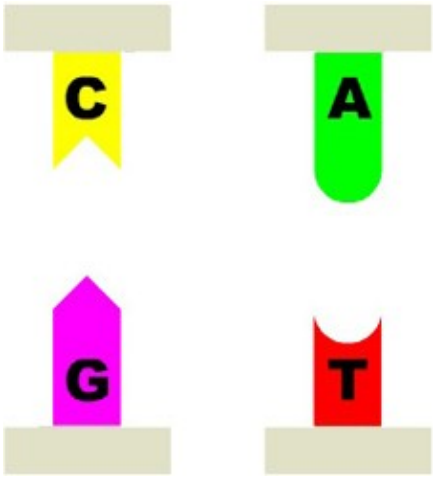
DNA is sometimes called a genetic blueprint because it contains all of the instructions that determine an individual's genetic characteristics.

Where is DNA Found?



A person's DNA is the same in blood, saliva, tissue, hair, semen, and other biological material. Biological material may be present at a crime scene even if it is not visible to the naked eye.

DNA Structure



DNA is comprised of four building blocks called bases. The building blocks are: **C**ytosine, **G**uanine, **T**hymine, **A**denine.

These are commonly referred to as C, G, T, A.

It is the order (sequence) of these building blocks that determines each person's genetic characteristics.

Rules of DNA

The online version of this course contains a multimedia [or downloadable] file. Visit this URL to view the file: http://forensic.dna.gov/module2/1/005

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

The specific combination of these bases through chemical bonds is known as base pairing.

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.

Online Link - Click here to view the website for the Human Genome Project.

The Double Helix

The structure of DNA is like a ladder with the base pairs forming the rungs of the ladder. The entire ladder is twisted upon itself like a spiral staircase to form the double helix.

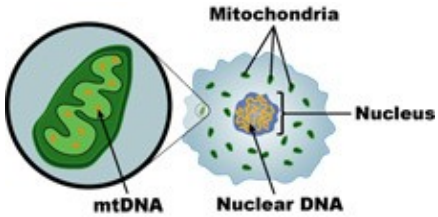
Forensic scientists look at many specific regions on the DNA double helix. Each of those regions has several base pairs (rungs), but no two humans, except identical twins, have the same combination of base pairs at all of the regions. Identical twins can not be differentiated based on regions currently tested by forensic scientists.

Click here to learn more about base pairs and the DNA double helix.

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.

The Two Types of DNA: Nuclear and Mitochondrial



Both nuclear DNA and mitochondrial DNA (mtDNA) are used in forensic DNA identity testing.

Nuclear DNA is found in the cell nucleus. Mitochondrial DNA is found in cell cytoplasm.

There are significant differences between these two types. Mitochondrial will be addressed in Module 8.

Nuclear DNA

Nuclear DNA is packaged into chromosomes within the nucleus of a cell. Nucleated cells contain 23 pairs of chromosomes (46 total): half inherited from each parent.

Notable exception: Each individual sperm contains only 23 chromosomes. Forensic scientists look at multiple sperm, which collectively provide the full complement of 46 chromosomes.

Click here to view an animation about how a child inherits genes from its parents.

Coding Versus Noncoding Regions

DNA has coding and noncoding regions. Coding regions are responsible for making proteins and are often called genes. Noncoding regions are those pieces of DNA between the coding regions that do not make any

known proteins.

Approximately 95% of a person's DNA is made up of noncoding DNA which is sometimes nicknamed "junk DNA" because it does not code for any physical characteristics or proteins. The name "junk" does not imply unreliability for identification testing.

Locus and Allele

A locus (or loci, plural) is the actual location of the gene on a region of a chromosome.

An allele is a different form of a gene at a particular locus. The designation of two alleles at a particular locus is a genotype.

Click here to view an animation about genes and loci.

Heterozygous versus Homozygous

A person's pair of alleles at a particular locus (genotype) is either homozygous or heterozygous .

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

Likewise, if two alleles are different at one locus, the person is *heterozygous* at that genetic location.

Click here to view an animation on genotypes.

Genotyping

There are three possible genotypes for any two alleles. For example, assume you have alleles 'B' and 'b' at a locus; the possible genotypes are BB, bb, and Bb.

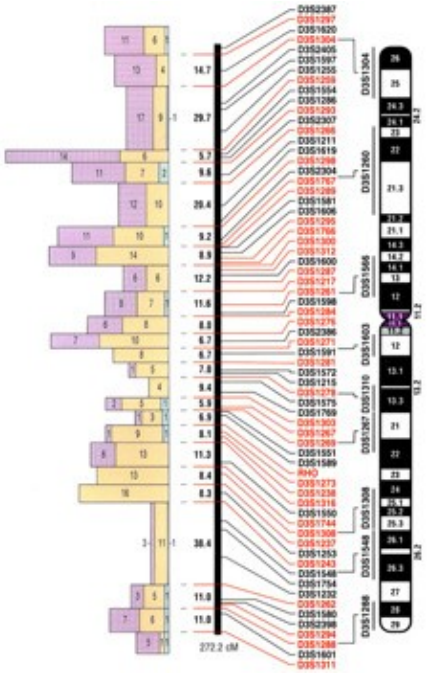
The genotypes BB and bb are the homozygous genotypes, and Bb is the heterozygous genotype.

Click here to view an animation on homozygous and heterozygous genotypes.

Basic Biology of Forensic DNA Identity Testing

The variation of genotype at multiple specific loci on the DNA is the foundation of forensic identity testing.

DNA Markers



"DNA marker" refers to a specific chromosomal location that is analyzed in the forensic DNA laboratory.

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.

In this example, the four base repeat is ATGC:

The online version of this course contains a multimedia [or downloadable] file. Visit this URL to view the file: http://forensic.dna.gov/module2/2/003

Continued

STRs (cont.)

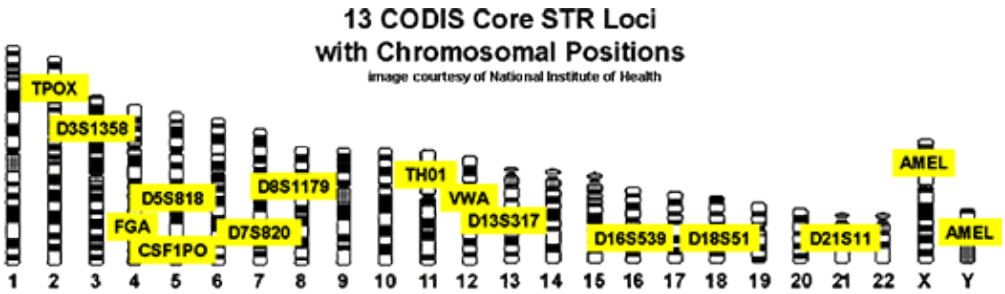
Multiple types of STRs can be analyzed in one test, or multiplexed, thus making the analysis process faster than previous technologies.

Multiplexed STRs are very valuable because they can produce results that are highly reliable for identification, even with old or minute biological samples.

STR Markers

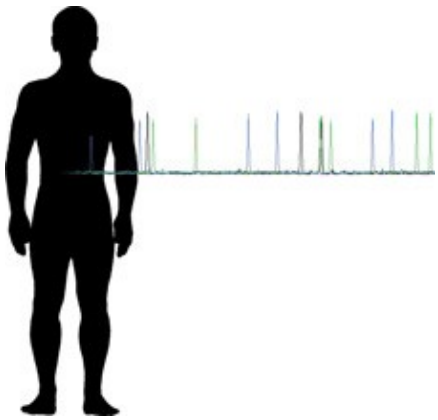
Research was conducted to select DNA markers from the polymorphic (variable) noncoding regions of the human genome for the purposes of forensic identity testing.

In the United States, the National DNA Database (CODIS) requires the use of 13 STR markers:



For more, access information about CODIS.

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.

More information on interpreting DNA laboratory reports can be found in

Module 6.

Continued

Forensic DNA Profile (cont.)

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.

The online version of this course contains a multimedia [or downloadable] file. Visit this URL to view the file: http://forensic.dna.gov/module2/2/007

Partial Profile

Sometimes, a partial match may be detected. This could occur if several of the loci tested are consistent between the evidence and the known, but the remaining loci yield no detectable alleles (this is different from an exclusion in which alleles *are* detected but are inconsistent).

Some laboratories may include a statement reporting a partial match.

Click here to view an animation on partial profiles.

Module Objectives Review

If you have successfully completed Module 2, you should be able to:

- Recognize basic biological terminology.
- Understand the basic biology of forensic DNA identity testing.

You have successfully completed Module 2, Biology of DNA. Proceed to Module 3, Practical Issues Specific to DNA Evidence.

Module Objectives

Upon completion of Module 3, you will be able to:

- Recognize crime scene issues relative to DNA evidence.
- Identify initial considerations in laboratory protocol.

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.

Crime scene documentation is an important resource for the evaluation of the integrity and condition of the evidence.

Online Link - View the NIJ brochure, *What Every Law Enforcement Officer Should Know About DNA Evidence* .

Online Link - Go directly to the *What Every Law Enforcement Officer Should Know About DNA Evidence* training program.

Potential Sources of DNA Evidence

Potential sources of DNA exist when biological material comes in contact with items. Some examples of items where DNA may be found are:

- Teeth
- Water bottles
- Gloves
- Earrings
- Watches
- Combs
- Eyeglasses
- Bitemarks
- Condoms
- Toothbrushes
- Chewed gum
- Toothpicks
- Used Tissues
- Licked stamps/envelopes
- Hats or sweatbands
- Bottles or cans
- Cigarette butts
- Clothing

Detection of Biological Material

Any item that is suspected of coming into contact with either the victim or the suspect may contain biological evidence. The following are examples of commonly used techniques for detection of biological material:

- Visual inspection of the crime scene.
- Examination with ALS (Alternate Light Source) or UV (Ultraviolet) light source.
- Examination with oblique lighting, such as the use of a flashlight held at a 45 degree angle.

- Chemical presumptive testing.

Click here for more information on presumptive testing.

Documentation

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 knife, 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.

Packaging

Dry items should be packaged in porous containers such as paper bags, envelopes, and folded paper. These types of containers allow air to pass through, reducing the possibility of damage to the DNA.

Wet items should be allowed to air-dry prior to packaging or layered with several sheets of clean paper to contain the stain and then placed in the appropriate container.

Very wet items can be transported in plastic containers but should be air-dried as soon as possible.

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

Degradation is the breaking down of DNA into smaller fragments by chemical or physical processes. Degradation of DNA may limit its use as evidence.

When DNA degrades, the DNA strand starts to break apart and these breaks can be at the sites where the DNA profiles are obtained. Because of the damage of the strand, none or only some of the 13 loci as required by the National DNA Database (CODIS) may be obtained. Access information about CODIS at http://www.fbi.gov/hq/lab/codis/index1.htm

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).

Continued

Degradation Factors (cont.)

Actions such as storing evidence in vehicle trunks, vans, office desks, direct sunlight, frost-free refrigerators and non-temperature/humidity-controlled facilities subject the biological evidence to increased heat, humidity fluctuations, and UV rays, all factors that can speed up degradation.

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.

Liquid samples should be transported in refrigerated or insulated containers.

Evidence should be stored in a temperature-controlled environment. Cool environments are preferred, although research has shown room temperature is suitable for storing dried stains, as long as the humidity is controlled.

Elimination Samples

In certain cases, elimination samples may be requested for DNA analysis. Elimination samples are used to help determine the value of a specific biological sample.

For instance, if a cigarette butt is recovered from a crime scene, elimination samples could be obtained from individuals who had access to the scene. This may show that the cigarette butt was left by the perpetrator.

Continued

Elimination Samples (cont.)

Elimination samples may also be required from the first responders, crime scene personnel and analysts working the case in an effort to associate all DNA profiles obtained from the evidence.

Reference Samples

To compare the victim's or suspect's DNA profile to the recovered crime scene DNA, the laboratory will need to have their known biological samples available for a side-by-side comparison. These known samples are called reference samples.

Many forensic laboratories will not examine the evidence unless reference samples are provided.

Continued

Reference Samples (cont.)

Keep in mind that individuals who have had bone marrow transplants or blood transfusions will typically have only the DNA profile of the marrow donor in their peripheral blood, while their other tissues (e.g., cheek swab) retain their own profile.

Probative Evidence

DNA is generally a very stable material and can remain intact for a long period of time. Thus, not every item at a crime scene should be considered probative evidence. The facts of the case along with other information will assist in making the determination of what evidence should be tested.

Example: A rape victim identifies her ex-boyfriend as the perpetrator. In this scenario, items at her place of residence where the assault occurred may have his DNA present from past consensual visits. Examination of these items would not necessarily provide useful information, yet the examination of the rape kit taken after the assault would show recent and possibly forced intercourse.

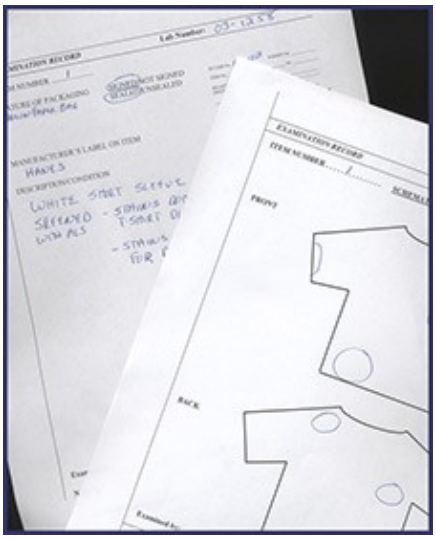
Continued

Probative Evidence (cont.)

The best evidence occurs when a victim's or suspect's DNA is found where it is not supposed to be or where information does not support contact having ever occurred between the victim and suspect.

Example: A breaking and entering occurred in a residential area; near the point of forced entry, a knit cap was found. The homeowners confirmed the knit cap was not theirs. No perspiration or other cellular transfer was found along the inside rim of the cap, which appeared new. However, several head hairs were recovered from inside. One of the hairs had a root with tissue attached and a DNA profile was obtained. This DNA profile may be used to identify the perpetrator.

Testing Considerations



Prior to DNA analysis, the case exhibits are described in the case notes. These notes will detail the physical attributes of the submitted items including the type of packaging, location of stains, and whether the stains were completely removed for further analysis.

Depending on the type of case and the total number of exhibits, complete examination, analysis, and review of the case can take from days to weeks. This time frame may be compounded by a laboratory's existing backlog. It is possible that a DNA case may not be examined until a year after submission.

Continued

Testing Considerations (cont.)

Although DNA analysis is a highly sensitive technique, it still requires a certain amount of biological material. If the sample is very small, it may be completely consumed in the analysis process. When possible, a portion of the original evidence is retained for future testing.

Prioritization

Each forensic laboratory has its own standard operating procedures on how cases are prioritized. In general, cases are analyzed according to date of receipt. The type of crime may affect prioritization. For example, homicides are usually given highest priority.

Module Objectives Review

If you have successfully completed Module 3, you should be able to:

- Recognize crime scene issues relative to DNA evidence.
- Identify initial considerations in laboratory protocol.

You have successfully completed Module 3, Practical Issues Specific to DNA Evidence. Proceed to Module 4, Introduction to the Forensic DNA Laboratory.

Module Objectives

Upon completion of Module 4, you will be able to:

- Understand and summarize the history and development of forensic DNA analysis.
- Recognize and understand the processes used in the laboratory for conducting a forensic DNA analysis.
- Identify the types of forensic DNA laboratories across the country and their capabilities.

History

The foundation for modern DNA testing originated in the application of conventional genetic marker typing methods, once the mainstay of forensic science.

Methods such as ABO blood typing and iso-enzyme (or protein) typing were used to compare biological evidence with known or reference samples.

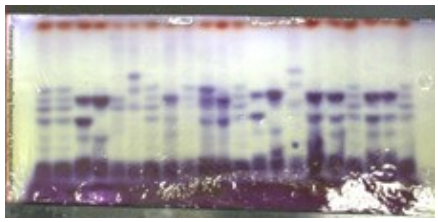
Click here to learn more about the history of DNA testing.

ABO Typing

Discovered in 1901 by Karl Landsteiner, the ABO system and its subsequent introduction into forensic science was just as remarkable in its day as DNA typing is today.

Although the ABO system was used to differentiate individuals, it did not have a high degree of discriminating power. Of the four possible groups: A, B, AB, and O - approximately 45% of the population has type O blood.

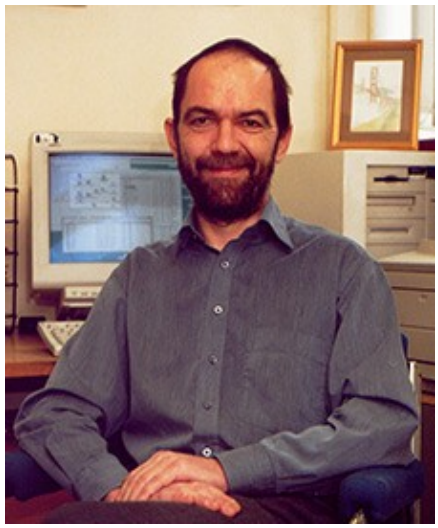
Iso-Enzyme and Protein Typing



First introduced into forensic applications in the 1970s, iso-enzyme and protein variant typing took the power of ABO grouping one step further. The typing of proteins and enzymes in biological evidence offered greater discriminating power, with some types occurring in less than 1% of the population.

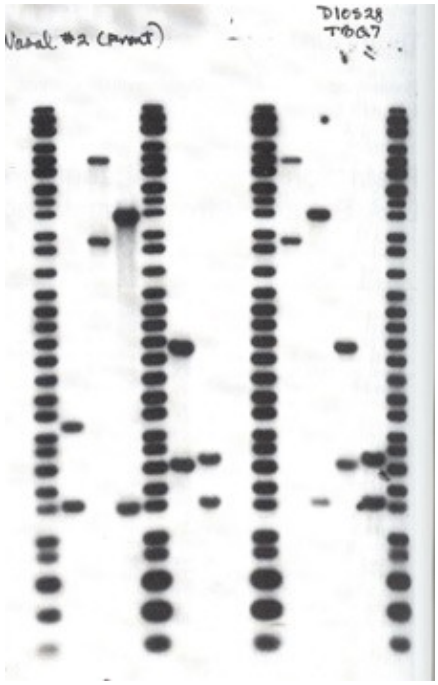
Iso-enzyme testing encouraged forensic scientists to perform more work with less sample, allowing one sample to be tested for multiple enzyme types.

DNA Typing



Forensic DNA testing as it is known today has a relatively short history. In 1985, Sir Alec Jeffreys developed a method to be used in forensic DNA identity testing. This method was based on the discovery that certain regions of the human genome contained segments of DNA that were repeated multiple times and exhibited a remarkable degree of genetic (and hence individual) variation.

DNA Typing - VNTRs



The regions of interests are called variable number of tandem repeats (VNTRs) and, with the exception of identical twins, people differ in the number of copies they have of a particular repeated DNA sequence. For example, a chromosome from one individual may contain 18 copies of a particular sequence whereas the same chromosome from a different individual may contain 25 copies of that same sequence.

DNA Typing - RFLP

The process used to examine the VNTRs from a forensic sample is called restriction fragment length polymorphism (RFLP). The technique takes advantage of the fact that the DNA fragment containing the 25 copies is larger than the corresponding fragment from the other chromosome containing the 18 copies.

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 Typing - PCR

The evolution of DNA testing advanced significantly when Dr. Kary Mullis discovered that DNA could be copied in the laboratory much as it is in the natural world.

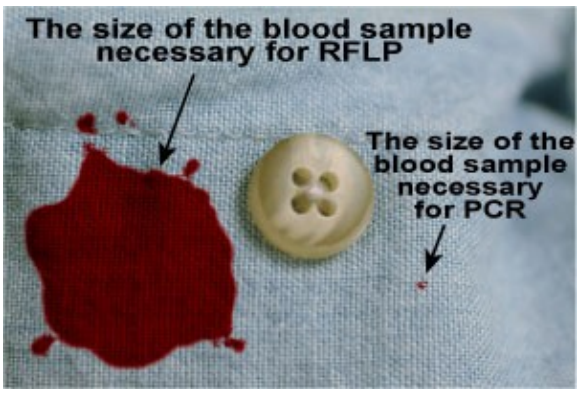
The copying process, known as polymerase chain reaction (PCR), uses an enzyme (polymerase) to replicate DNA regions in a test tube. By repeating the copying process, a small number of DNA molecules can be reliably increased up to billions within several hours.

Polymerase Chain Reaction (PCR) Process

PCR is a 3-step process:

1. Extraction
2. Amplification
3. Detection

DNA Typing - The PCR Revolution

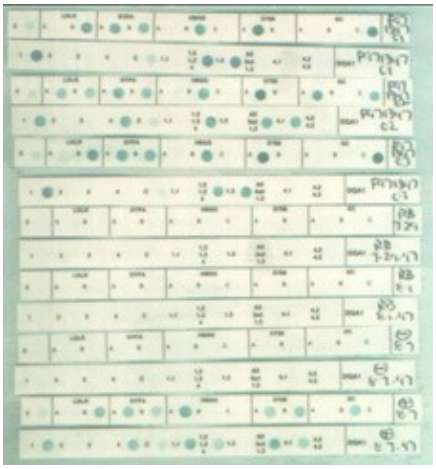


While RFLP technology provided the ability to individualize samples to their donors, it required a large amount of biological sample and the presence of high-quality (non-degraded) DNA. RFLP testing averaged

10-12 weeks to complete.

PCR technology permitted very small samples and partially degraded DNA to be tested. It also shortened the analysis time from weeks to days. This technology is the primary reason why DNA testing is increasingly being used today as an investigative tool for law enforcement.

DNA Typing - DQa(DQA1)/ Polymarker



The first forensic application of PCR used the HLA DQ-alpha (DQA1) system which was expanded to include additional genetic systems called Polymarker (PM).

Although DQa/Polymarker was faster and more sensitive than RFLP, results were less discriminating. For example, matching profiles might be found in one in several thousand people. In RLFP, the match could be one in several million.

DNA Typing - Short Tandem Repeat

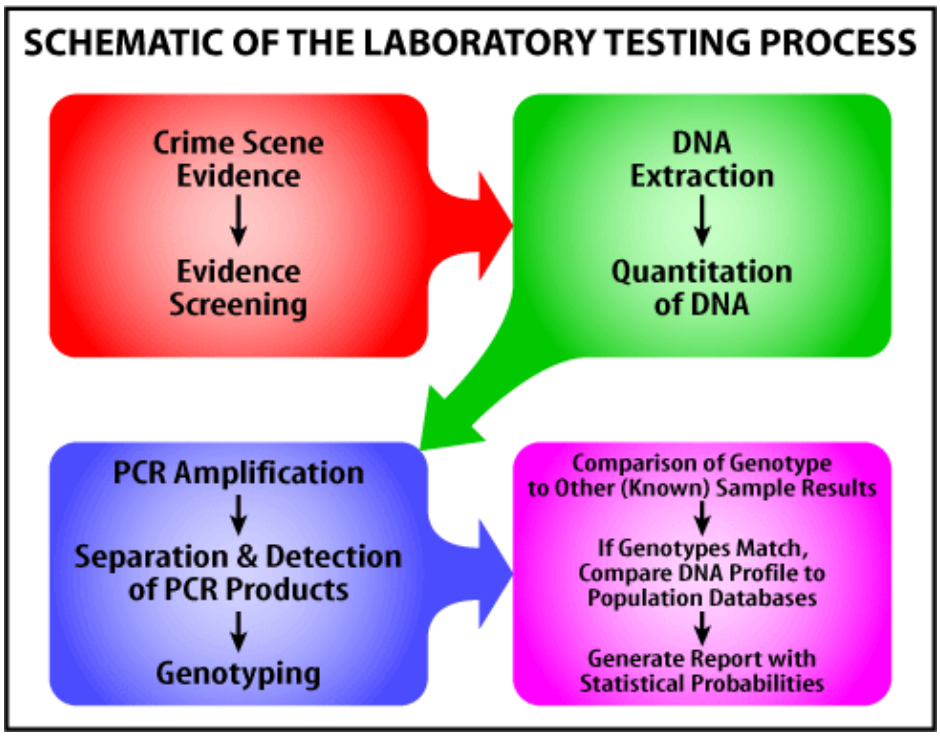
The current state-of-the-art DNA testing utilizes short tandem repeat (STR) technology which combines the best features of RFLP and PCR.

This method examines a subclass of VNTR regions of the DNA molecule that tend to *repeat* themselves in *short*, adjacent, or *tandem,* segments. STR technology can use partially degraded, small quantity DNA and has a very high degree of discrimination.

'Multiplex' STRs are groups of genetically independent STR markers that can be examined at the same time. These multiplexes have proven to be very successful and provide the basis for the local, state and national DNA database entries.

The online version of this course contains a multimedia [or downloadable] file. Visit this URL to view the file: http://beta.forensic.dna.devis.com/module4/1/011

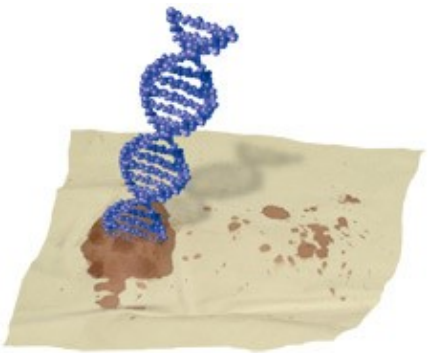
Laboratory Process Used in Forensic DNA Analysis



Evidence Screening

The first step performed in the laboratory is the screening of the evidence. The evidence is inventoried, documented, and evaluated for useful biological evidence. Once stains or other biological material of interest are located, they may be subjected to presumptive and confirmatory testing in an attempt to identify the type of biological material present (e.g., blood, semen, saliva).

DNA Extraction



DNA extraction is the process of separating DNA from other cellular material contained in the biological evidence recovered. This is one of the most labor-intensive procedures of the DNA analysis. The DNA extraction process requires careful handling of biological material to prevent sample contamination.

Click here for more information on commonly used extraction techniques.

DNA Quantitation

Most PCR-based analysis techniques require the analyst to know the quantity of DNA obtained after extraction. Quantitation is the method used to determine the quanitity of "x" in a given sample:

- Too much DNA used in the analysis can give results that hinder determining the number of people involved or cover up other DNA profiles.
- Too little DNA may only provide a partial profile.

Click here for more information on DNA quantitation techniques.

STR Amplification

Amplification uses the PCR process to create copies of specific DNA target regions from the original sample. The STR amplification process also incorporates chemical labels (e.g. fluorescent dyes) for subsequent detection of target alleles.

The actual procedure involves the heating and cooling of samples in a specific pattern in an instrument called a thermal cycler. After approximately 30 cycles, a 'PCR Product' (amplicon or amplified product) is created and subsequently tested.

The online version of this course contains a multimedia [or downloadable] file. Visit this URL to view the file: http://forensic.dna.gov/module4/2/005

Stochastic Effects in DNA Amplification

Sometimes forensic evidence samples contain quantities of DNA that are very small. When an analyst tries to copy the DNA using PCR, the result can be an unbalanced representation of the alleles present and in an extreme case can cause allelic dropout. This can make interpretation of the data difficult and may result in an improper reporting of the DNA profile.

See definition of stochastic effects.

Click here to view an animation on allelic dropout.

DNA Separation

For genotyping to occur, the extracted and now amplified DNA must be separated so that alleles can be differentiated from each other. There are two primary methods used for DNA separation: slab gel electrophoresis and capillary electrophoresis (CE). These techniques produce identical results in a variety of visual formats.

The electrophoresis process uses an electric field to separate negatively charged DNA based upon the size of the amplified fragments.

The online version of this course contains a multimedia [or downloadable] file. Visit this URL to view the file: http://forensic.dna.gov/module4/2/007

DNA Detection

After the DNA molecules have been separated by electrophoresis, the different DNA types, or alleles, must be detected. As a result of the amplification process, the different STR loci are prelabeled with different colored fluorescent dyes. Their respective alleles are detected by a laser that scans across the slab gel or capillary. On a slab gel, this is sometimes seen as colored bands that are captured in a digital image. An electropherogram, which is a recording of colored peaks, is produced on the CE instrument and some slab gel systems.

Click here to view an animation on how an electropherogram is generated.

DNA Detection - Equipment

Current and past manufacturers of DNA detection equipment include:

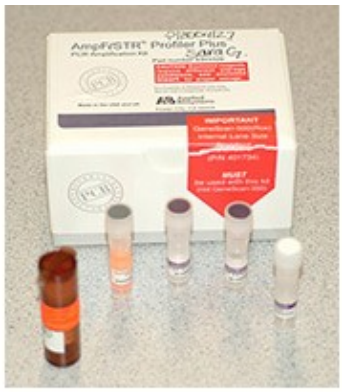
- Applied Biosystems (ABI)
- Hitachi

Major DNA detection kits:

- Applied Biosystems
- Promega

Click here for more information on DNA detection equipment.

DNA Detection - Kits



All of these kits have been designed to permit the analysis of the 13 COmbined DNA Index System (CODIS) core loci, which consist of a set of 13 STR markers that have been adopted nationwide for forensic purposes. CODIS refers to the National DNA Database, which is a searchable repository of DNA profiles from convicted offenders, crime scene samples and missing persons. Access information about CODIS at http://www.fbi.gov/hq/lab/codis/index1.htm.

Data Interpretation

Forensic DNA analysts must convert fluorescence data that is either in the form of bands on a gel or peaks on an electropherogram into information that can be shared and communicated with lay persons.

Click here to view an animation that explains more about electropherogram interpretation.

This process requires taking multicolor fluorescent information generated during testing and translating it into genotypes, which is the specific genetic profile of a sample.

An STR profile is simply a series of numbers that represents all of the genotypes detected in a particular sample for each locus, or area of the DNA molecule, that is examined. This information is communicated in a report that is generated by the laboratory.

Click here to view an animation that explains more about how a profile is derived from an electropherogram.

DNA Analysis Reports

Analytical reports issued by forensic DNA laboratories can vary widely in format and content. Reports may contain the results of any additional non-DNA tests performed to locate and characterize the type of biological evidence present.

For more information on laboratory reports, see Module 6.

Laboratory Structure

The crime lab systems in operation across the country vary in structure. Public crime labs may be federal-, state-, county-, or city-sponsored. Many public labs are associated with a law enforcement entity; some are associated with a district attorney's office, while others are independent government entities. Some forensic laboratories are privately held companies.

Not all laboratories are capable of providing comprehensive and complete forensic services. Some do not have the capability to conduct DNA testing and may need to contract out their DNA cases to other agencies or private corporations.

Continued

Laboratory Structure (cont.)

Not all laboratories are capable of the same DNA testing either. Most DNA labs have the capability to conduct testing on nuclear DNA, which is the single copy of DNA that exists in every cell nucleus. A select few specialize in Y-STR testing, which is DNA conducted on the Y-chromosome, which is found only in males.

Others specialize in testing mitochondrial DNA (or mtDNA), which is found in every cell of the body regardless of the presence of a nucleus.

These specialized DNA tests (Y-STRs and mtDNA) will be discussed in more detail in Module 8.

Module Objectives Review

If you have successfully completed Module 4, you should be able to:

- Understand and summarize the history and development of forensic DNA analysis.
- Recognize and understand the processes used in the laboratory for conducting a forensic DNA analysis.
- Identify the types of forensic DNA laboratories across the country and their capabilities.

You have successfully completed Module 4, Introduction to the Forensic DNA Laboratory. Proceed to Module 5, Assuring Quality in DNA Testing.

Module Objectives

Upon completion of Module 5, you will be able to:

- Understand the general principles of quality assurance.
- Understand the development and application of standards that apply to forensic DNA testing.
- Use that knowledge to evaluate the reliability of testing.

Introduction to Quality Assurance

Quality Assurance (QA) consists of all the planned and systematic actions necessary to demonstrate that a product or service meets specified requirements for quality.

The planned and systematic actions are documented in the laboratory quality manual and standard operation procedures (SOP).

In forensic DNA testing the expectation is that the true DNA profile is reported, together with a correct interpretation and an accurate statistical description of its rarity.

Factors Affecting Quality

Many factors determine the correctness and reliability of the tests performed by a laboratory. They include:

- Human factors
- Accommodation and environmental conditions
- Test methods and method validation
- Equipment
- Handling of test items

Human Factors

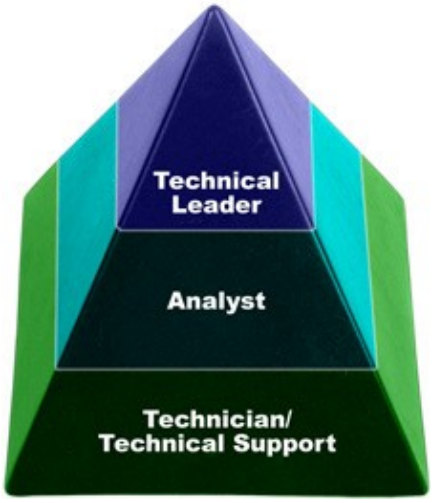
The range of tasks involved in DNA testing is considerable. In some laboratories, each group of tasks is allocated to an appropriately skilled person. At the other extreme, one person will conduct all the tasks from sample identification, to extraction and preliminary processing of the DNA, to amplification, to typing and reporting. In every case, best quality depends on the person:

- Having the required understanding of the principles behind the task (knowledge).
- Having been trained in the processes required (skills).
- Having shown that they can apply that training in a reliable manner (abilities).

The combination of demonstrated knowledge, skills and abilities defines the *competency* of the individual.

Continued

Human Factors (cont.)



A range of personnel can be involved in a DNA laboratory, including:

- Technical Leader
- Analyst
- Technician (technical support)

Technicians/Technical Support

Technicians (Technical Support):

- Usually do not have a 4-year degree.
- Conduct repetitive tasks under supervision.
- Must demonstrate competency and participate in proficiency testing.
- Are responsible for their work (e.g., sign worksheets but do not write reports or testify).

Click here to view the section within the *DNA Advisory Board Quality Assurance Standards for Forensic DNA Testing Laboratories* on technical support personnel.

Analyst

Analysts:

- Must have a 4-year degree with specific content.
- Must demonstrate competency and participate in proficiency testing. May be totally responsible for all steps in testing or may be supported by technicians.
- Write reports and testify.

Click here to view the section within the *DNA Advisory Board Quality Assurance Standards for Forensic DNA Testing Laboratories* on analysts.

Technical Leader

Technical Leaders:

- Must have a graduate degree and must meet other specific educational and experience requirements.
- Are responsible for the validity of all technical operations.
- Range from a senior manager with supervisory and reporting responsibilities to an off-site contractor with no supervisory or reporting responsibilities.

Click here to view the section within the *DNA Advisory Board Quality Assurance Standards for Forensic DNA Testing Laboratories* on technical leaders.

Physical Facilities and Environment Conditions

Physical facilities and environmental conditions should:

- Prevent contamination
- Prevent sample and reagent degradation
- Ensure that scientific equipment is operating within its design specifications

Continued

Physical Facilities and Environment Conditions (cont.)

For example, one of the pieces of scientific equipment widely used in DNA testing, the ABI 310, generates heat during operation but requires a stable environmental temperature to give consistent results. The laboratory should ensure that the air conditioning (A/C) around the 310 is adequate. This is sometimes achieved by isolating the equipment in a space with a local A/C unit.

Another example is the widespread use of freezers and refrigerators for sample and reagent storage.

Methods and Method Validation

DNA methods are subjected to extensive and rigorous evaluation before being accepted for routine use. The process is termed validation.

The degree of rigor is contextual: a proposed new DNA typing system undergoes extensive validation, including peer review and publication. The introduction of an established technology to an individual laboratory requires less rigorous validation. The first instance requires that the underlying characteristics of the testing are established. The second requires only that the laboratory is able to implement the established procedure correctly.

Click here for more information on differentiating new technology from a new technique.

Equipment

Laboratories depend on equipment to process samples and produce the final result. The laboratory should be able to show that the equipment is working correctly each time it is used. This is achieved through calibration and maintenance programs, which define the calibration processes and the schedule for their application.

Handling of Test Items

Forensic science places stringent requirements on the handling of test items to ensure their integrity. Chain of custody and retention of samples for retesting are non-technical examples.

In regard to testing, the laboratory must have and apply procedures to protect test items from avoidable loss, contamination, and degradation. These begin with the packaging and preservation of samples and apply continuously through processing, testing, and short- and long-term storage.

Controlling Quality

Quality control (QC) consists of the operational techniques and activities that are used to fulfill requirements for a successful quality assurance program. Typical QC activities include:

- Regular use of certified reference materials and/or internal quality control using secondary reference materials
- Participation in inter-laboratory comparison or proficiency testing programs

Use of QC Samples

Laboratories have access to samples of known composition that can be processed with each batch of unknown (casework) samples. These are known as control samples (QC samples). These control samples may be purchased and have a certificate of authenticity, or may be produced by the laboratory (e.g., from donors).

Continued

Use of QC Samples (cont.)

The QC sample allows the analyst to confirm the overall quality of the batch run. If the result from the QC sample is as specified, the inference is that the whole batch was correctly processed. QC samples include a range of negative (or blank) samples as well as positive ones.

Certified reference materials are the most rigorous example of a QC sample. Their composition is certified to a national standard reference material. Such samples are an important part of validation and confirmation of performance of methods.

Online Link - Click here to access National Institute of Standards and Technology, Office of Law Enforcement Standards, Standard Reference Materials for the Forensic Sciences web page.

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.

There are different types of proficiency tests:

- An external test is created and administered by an outside agency
- An internal test is created and administered by the laboratory itself
- In a blind test, analysts do not know they are being tested. In most forensic DNA laboratories, blind tests are not used

Online Link - Click here to view the NIJ report, Developing Criteria for Model External DNA Proficiency Testing.

Best Practice Standards in the Forensic DNA Laboratory

Best Practices and Standards

The forensic DNA community has a long history of identifying and recommending best practices and supporting the development of Federal Bureau of Investigation (FBI) standards:

- The Technical Working Group on DNA Analysis Methods (TWGDAM) http://www.cstl.nist.gov/biotech/strbase/twgdam1.htm
- The DNA Advisory Board (DAB) http://www.cstl.nist.gov/biotech/strbase/dabqas.htm
- The National Quality Assurance Standards for DNA Testing (QAS) http://www.fbi.gov/hq/lab/codis/qualassur.htm
- The Scientific Working Group on DNA Analysis Methods (SWGDAM) http://www.fbi.gov/hq/lab/fsc/backissu/july2000/swgroups.htm

TWGDAM

In 1989, the FBI formed the Technical Working Group on DNA Analysis Methods (TWGDAM) which brought together scientists from state, local, and federal laboratories and the academic community to address how this new technology would be implemented.

One of TWGDAM's first tasks was to establish quality assurance guidelines, which were published in 1990 and later updated. Courts often relied on these in making admissibility decisions.

The DNA Advisory Board (DAB)

The DNA Identification Act of 1994 established the DNA Advisory Board (DAB) to recommend national quality assurance standards to the FBI Director.

The DAB was chaired by Nobel prize winner Dr. Joshua Lederberg, and included representatives from a wide range of operational and academic laboratories, as well as the National Institute of Standards and Technology (NIST). Access the NIST webiste at http://www.nist.gov.

Implementation of the standards (on October 1, 1998) effectively ended the DAB's work. Responsibility for maintenance and development was passed to the Director of the FBI, advised as required by TWGDAM.

The National Quality Assurance Standards (QAS)

The "Quality Assurance Standards for Forensic DNA Testing Laboratories" and the "Quality Assurance Standards for Convicted Offender DNA Databasing Laboratories" were issued by the Director of the Federal Bureau of Investigation (FBI) in October 1998 and April 1999, respectively.

These standards define the requirements that must be met by any laboratory conducting DNA testing that wishes to participate in the National DNA Index System (NDIS) or to apply for federal funding to support its DNA testing.

Continued

Click here to access the *Quality Assurance Standards for Forensic DNA Testing Laboratories.*

Click here to access the *Quality Assurance Standards for Convicted Offender DNA Databasing Laboratories.*

Online Link - Click here to view the NIJ report, - Developing Criteria for Model External DNA Proficiency Testing.

The National Quality Assurance Standards (QAS) (cont.)

The QAS provide comprehensive coverage of significant factors, namely:

- Definitions
- Organization and Management
- Facilities
- Validation
- Equipment Calibration and Management Review (More information on equipment will be found in Module 5 Topic 1)
- Corrective Action
- Subcontractors
- Safety
- Quality Assurance Program
- Personnel
- Evidence Control
- Analytical Procedures
- Reports
- Proficency Testing
- Audits

Continued

The National Quality Assurance Standards (QAS) (cont.)

Although the QAS define standards of operation, each is capable of interpretation as to how it can be met. For that reason, the FBI convened a working group to develop a consensus checklist to use when auditing against the standards.

The checklist, which was first published in October 2000 and updated in 2004, contains extensive discussion for most standards describing what is required to demonstrate compliance. For example, brief mention was made previously of the education and experience required by a technician, an analyst, and a technical leader. The consensus checklist provides specific and detailed elaboration of what is required to satisfy the QAS standards for education of personnel.

The checklist is the primary reference source for detail on what constitutes consensus best practice in DNA testing.

Click here to view audit information contained in the *DNA Advisory Board Quality Assurance Standards for Forensic DNA Testing Laboratories*.

SWGDAM

TWGDAM changed its name to SWGDAM (Scientific Working Group on DNA Analysis Methods) in 1999.

All duties described in the DAB standards as falling to TWGDAM are met by its successor.

Accreditation and Certification

Accreditation is the formal assessment and recognition by an impartial competent authority that a laboratory is capable of meeting and maintaining defined standards of performance, competence and professionalism. It is a powerful tool to ensure compliance with standards, and was recognized as such in the original DAB report.

Certification is the process by which an organization evaluates the qualifications of an individual to perform a specific task or function. Certification of persons indicates that an individual possesses specific knowledge, skills or abilities in the view of the certifying body.

Although accreditation and certification are powerful tools for quality assurance, neither is currently a prerequisite for admissibility. (*State v. Adams* 984 P.2d 16 (Ariz. 1999); *Smith v. State* 702 N.E.2d 668 (Ind. 1998); *State v. Ramsey* 550 S.E.2d 294 (S.C. 2001); *J.H.H. v. State* Ala.Ct.App., CR-02-1752, 2004 (1/30/04) Ala.Crim.App. LEXIS 22.) 1

Accreditation


FQS-I

Forensic Quality Services - International

July 1, 2004

CODIS Laboratory

We now have David Epstein and Lucy Houck's report on your corrective actions and are pleased to inform you that they have determined that your laboratory complies with the requirements of ISO/IEC 17025 and NFSTC Forensic Requirements for Accreditation (FRA 1) and FRA 2 (the Quality Assurance Standards for Convicted Offender DNA Databasing Laboratories as issued by the Director of the FBI in April, 1999.)

Your certificate is enclosed.

Please note the following:

- The certificate expires on July 1, 2006.
- Per NFSTC requirements for annual surveillance, you must send us a report showing satisfactory completion of an internal audit and records showing objective proof of your ongoing compliance with proficiency testing requirements. It is your responsibility to make sure that that audit is conducted in a timely manner. NFSTC reserves the right to require an on-site surveillance visit during the second year of this two-year cycle.

The certificate is valid only for the facility and scope listed on the certificate. Any changes in physical plant, methodology, or signatory personnel must be reported to NFSTC for review and modification of our records.

Also, please supply us with a list of all signatories responsible for test certificates or test reports. This list will be kept in our files and you must notify us of any additions or deletions.

An independent corporation established by the NFSTC

At present there are two agencies in the U.S. that are recognized by the NDIS Board as meeting the requirements of the Justice For All Act for accreditation of DNA testing laboratories:

- The American Society of Crime Laboratory Directors Laboratory Accreditation Board. Access the ASCLD/LAB website at http://www.ascld-lab.org/
- The Forensic Quality Services - International (FQS-I). Access the FQS-I website at http://www.forquality.org/fqs_I.htm

Both use the consensus QAS Audit checklist to ensure that DNA testing complies with the QAS.

Certification

The American Board of Criminalistics (ABC) provides certification programs for DNA analysts, as well as for general forensic scientists.

Programs of ABC certification include:

- Diplomate (D-ABC)
- Fellow (F-ABC)
    - ♦ Forensic Biology
    - ♦ Drug Analysis
    - ♦ Debris Analysis
    - ♦ Trace Evidence

- Technical Specialist (TS-ABC)
    - ♦ Drug Analysis
    - ♦ Molecular Biology

AMERICAN BOARD OF CRIMINALISTICS

Online Link - Click here to go to the American Board of Criminalistics website at http://www.criminalistics.com/.

Significance of Quality Assurance

Quality assurance is simply what its name says: a tool to assure the quality of testing.

The key points to follow:

- Development and adoption of best practice standards and their rigorous implementation are preferred.
- However, best practices are not the only way to get the right answer nor does using them mean that there will never be an error (either an incorrect positive result or a negative one that should have been positive).

Understanding Limitations

Laboratories can produce accurate testing without complying with all consensus standards or without accreditation. Each instance of evaluation of results from a laboratory that is not accredited, or that may be questioned in regard to compliance with a specific standard, must be considered on a situational basis.

For example, Standard 17 of the QAS refers to subcontracting. A laboratory that subcontracts may not meet this standard and so would not be accredited. However, that finding has no significant bearing on the validity of its own testing. Another example is that a laboratory may not have complied with the letter of its policy and procedures on equipment calibration, but may be able to demonstrate that all its QC measures were satisfied.

Scientifically, these situations have to be judged on the likely impact on the quality of the specific test results.

Legally, non-conformances may become relevant in assessing DNA evidence admissibility or weight.

Continued

Understanding Limitations (cont.)

Even the DAB has recognized that there is more than one way to ensure quality. The Introduction to the original DAB standards states: "...The standards are quality assurance measures that place specific requirements on the laboratory. Equivalent measures not outlined in this document may also meet the standard if determined sufficient through an accreditation process."

Module Objectives Review

If you have successfully completed Module 5, you should be able to:

- Understand the general principles of quality assurance.
- Understand the development and application of standards that apply to forensic DNA testing.
- Use that knowledge to evaluate the reliability of testing.

You have successfully completed Module 5, Assuring Quality in DNA Testing. Proceed to Module 6, Understanding a Forensic DNA Lab Report.

Module Objectives

Upon completion of Module 6, you will be able to:

- Understand the basic elements contained in forensic DNA laboratory reports.
- Understand common terminology used in DNA laboratory reports.
- Understand the DNA laboratory results and their overall significance as evidence in the case.

Basic Elements of a Forensic DNA Laboratory Report

National standards exist for reporting DNA analysis, however, laboratories differ as to the information provided in the analytical report. Basic elements that commonly appear in reports include the following:

- Administrative information on the case, such as agency, file number, evidence item numbers, victim name and suspect name.
- Date of the report and the name and signature of the reporting analyst
- Types of evidence items examined, and type of methodology or technique used to examine the evidence.
- Results of the examination and/or conclusions.
- Interpretation of the resultant data.
- Disposition of evidence.

Reports may contain the results of any additional non-DNA tests performed to locate and characterize the type of biological evidence present.

Click here to see the National DNA Quality Assurance standards for a DNA laboratory report.

Click here to see a sample DNA laboratory report.

Interpretive Statement

Some laboratories include genotype data in their reports, usually in the form of a table.

Reports will contain an interpretive statement. The statement will address whether DNA profiles from evidence samples could be associated with or excluded as the source of:

- A known individual (suspect, victim, third party)
- Other evidence samples (scene samples, sexual assault evidence)
- Database samples (offenders, forensic unknowns, or missing persons)

If one or more of the known samples is consistent with any of the evidence samples, the report may provide a statistical frequency. More information can be found in Module 7.

Formal Reports versus Case Folder and Other Supporting Documents

In addition to the laboratory analytical report, several additional documents may be available from the laboratory related to the case.

The National DNA Standards require that laboratories maintain a case file containing all records generated by examiners related to case analysis. Case files commonly include:

- A chain of custody for all items received by the laboratory.
- Any sketches or photographs taken in the laboratory.
- Examination (bench) notes by the analyst of all steps taken in testing.

Continued

Formal Reports versus Case Folder and Other Supporting Documents (cont.)

- Laboratory logs or standard forms related to testing.
- Data in the form of strips, photographs, copies of autoradiographic film, electropherogram data, and so forth.

In addition to the information in the case file, documents that could be available from the laboratory related to the testing include:

- Equipment calibration and maintenance records.
- Analyst training and proficiency test records.
- Unexpected results and/or corrective action reports.

Inclusion or Match

When comparing a known sample to an evidence sample, the donor of the known is included as a source of the evidence if the profiles are the same. This can either be referred to as an inclusion or a match . For more

information on an electropherogram see Module 4, Data Interpretation .

The significance of the inclusion or match will depend on the statistical data obtained. More information can be found on statistics in Module 7.

Click here to see an animation of a matching DNA sample.

Exclusion or Non-match

When comparing a known sample to an evidence sample, the donor of the known is excluded as a source of the evidence if the profiles are different. This can either be referred to as an exclusion or a non-match .

When an individual is excluded as the source of DNA, it does not necessarily mean the individual was not involved. For example, a true perpetrator who left no detectable biological material will be excluded as a source of DNA.

Click here to see an animation of an excluded DNA sample.

Inconclusive or Uninterpretable

Sometimes no conclusion can be drawn as to whether a known individual is included or excluded as the source of DNA evidence. Inconclusive or uninterpretable results may be due to such complicating factors as multiple contributors, contamination, or degradation of samples. Inconclusive or uninterpretable results should not be interpreted as an exclusion.

Click here to see an animation of an uninterpretable sample DNA laboratory report.

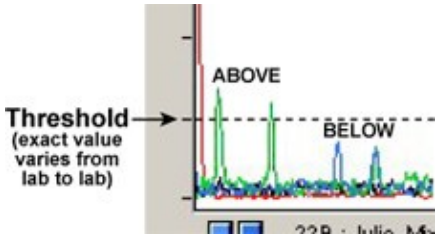
No Results

Sometimes testing of a sample is attempted but no results are obtained. This could indicate:

- Absence of DNA in the sample.
- Insufficient DNA was present in the sample.
- Extensively degraded DNA.
- Presence of a substance that inhibits the PCR process (PCR inhibitor).

Click here to see an animation of a sample DNA laboratory report with no results.

Data Interpretation - Thresholds



A threshold amount of amplified DNA must be observed before a laboratory will report an allele or genotype. Threshold values can differ among laboratories and are based on internal validation studies that are used to establish guidelines. Laboratory guidelines will determine whether data under the threshold is reported.

Single Source

DNA from one contributor is commonly referred to as a single source sample.

Single source profile could be derived from:

- A reference sample (victim or suspect).
- An elimination sample (first responders, EMT personnel, consensual sex partners, or anyone who might have had authorized access to the crime scene).
- A crime scene sample (bloodstain, chewed gum, cigarette butt).

Interpreting Mixtures

Mixtures of DNA from more than one contributor are commonly encountered. Mixtures of more than one contributor could be due to:

- Actual contribution by multiple donors during the crime.
- Presence of exogenous DNA on the substrate prior to the evidence sample being deposited.
- Contamination during crime scene processing and sample handling (collection, packaging or testing).

Any biological material (blood, semen, saliva, sweat, hair, or other cells left behind after contact) can all be mixed and found in combination with any other.

Click here to view a sample laboratory report containing contact evidence.

Click here to see an animation demonstrating how DNA mixtures at a crime scene can occur.

Continued

Interpreting Mixtures (cont.)

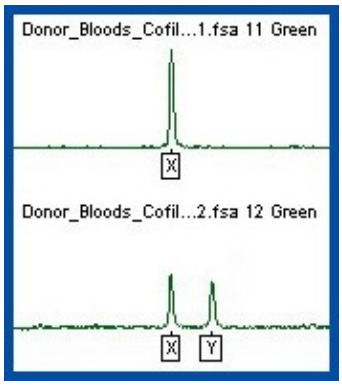
Current DNA technologies are sensitive and can detect DNA in minute amounts. Most DNA analysis systems are also able to estimate the relative quantity of each profile contributing to the DNA mixture. Laboratory reports may classify certain profiles as belonging to a major contributor and/or a minor contributor. When more than one profile is detected in a sample, laboratories may differ in how this information is reported.

Click here to view an example of a laboratory report containing a major contributor profile.

Click here to view an example of a laboratory report containing a minor contributor profile.

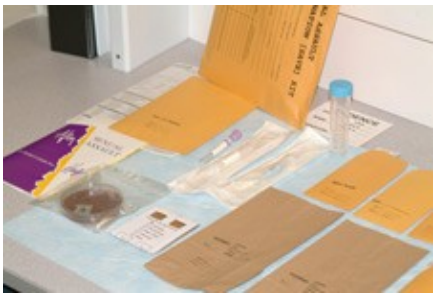
Click here to see an animation of a laboratory report determining the major and the minor contributor.

Gender Typing



When amelogenin (found on sex chromosomes) is tested, the gender of the donor of a sample may be determined. Generally, females type as XX and males types as XY. The amelogenin data may aid in interpretation of a mixture containing male and female DNA.

Special Interpretation Considerations Related to Sexual Assault Cases: Differential Extraction



In cases with sexual assault evidence, a differential extraction procedure is commonly used to separate sperm cells from all other cells present. If the extraction is efficient, sperm cells will end up in one tube and all other material will end up in another tube. These two separated portions are referred to as fractions .

Continued

Special Interpretation Considerations Related to Sexual Assault Cases: Differential Extraction (cont.)

Labs may report these two fractions as:

- Male fraction and female fraction (though in a male on male assault, these terms may be misleading).
- Sperm fraction and non-sperm fraction.
- S (sperm) fraction and E (epithelial) fraction.
- Fraction 1 and fraction 2.

Complete separation may not be possible for a variety of reasons. In such cases, one or both fractions may contain a mixture of sperm and non- sperm DNA. This does not necessarily preclude interpretation of results.

Note: the remainder of the module will use the terminology sperm and non-sperm fractions.

Continued

Special Interpretation Considerations Related to Sexual Assault Cases: Small Sperm Sample Amounts

In situations where the amount of sperm DNA is small, only victim DNA may be detected in both the sperm and non-sperm fractions. In that case, the report may state that the victim cannot be excluded as the source of DNA from both the sperm fraction and non-sperm fraction.

Depending on laboratory policy, conclusions may or may not be reported regarding the sperm donor.

Therefore, the absence of evidence is not evidence of absence.

Continued

Special Interpretation Considerations Related to Sexual Assault Cases: Small Sperm Sample Amounts (cont.)

In cases where the number of sperm cells are relatively small compared to the number of victim cells, the laboratory report may recommend other appropriate testing (e.g. Y-STR) to aid in the investigation.

More about DNA analysis methods can be found in Module 8 Topic 4 and Module 15 Topic 1 later in this PDF.

Statistical Statement

If the profiles from the evidence sample and the known sample are the same, reports will usually include a statistical statement such as:

The frequency estimate of the DNA profile found in sample A is:
1 in X for Caucasians
1 in Y for African Americans

1 in Z for Hispanics

The larger the number in the frequency estimate, the more rare the genetic profile detected in the evidence (and the known sample). For more details on statistics and statistical reporting, see Module 7.

Module Objectives Review

If you have successfully completed module 6, you should be able to:

- Understand the basic elements contained in forensic DNA laboratory reports.
- Understand common terminology used in DNA laboratory reports.
- Understand the DNA laboratory results and their overall significance as evidence in the case.

You have successfully completed Module 6, Understanding a Forensic DNA Laboratory Report. Proceed to Module 7, Statistics and Population Genetics.

Module Objectives

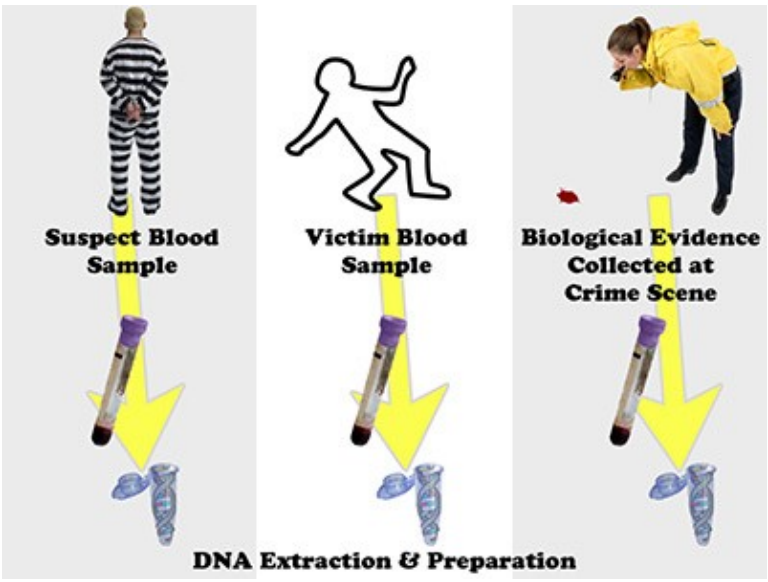
Upon completion of Module 7, you will be able to:

- Understand why statistical estimates are provided for forensic DNA evidence.

- Understand the concepts relating to determination of allele frequencies in human populations and how they relate to DNA profile frequency estimates.
- Understand special considerations affecting the interpretation of DNA evidence.

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).



Continued

Comparing Genetic Profiles (cont.)

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."

For a review of the laboratory interpretation of DNA evidence, refer to Module 6.

Continued

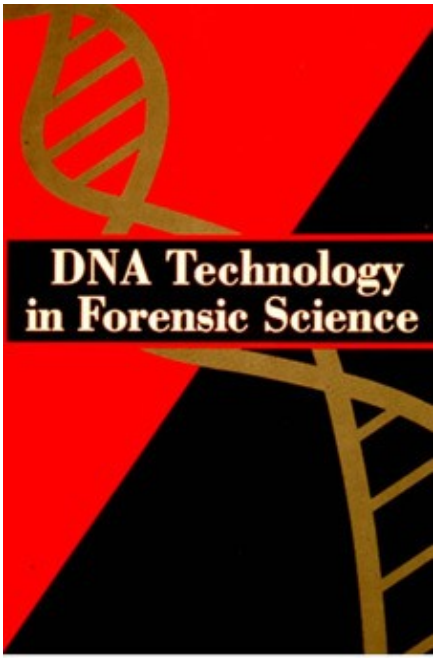
Statistical Interpretation of the Evidence (cont.)

In a given population, any particular 13-locus short tandem repeat (STR) profile is rare because there are many distinct alleles at each of these STR loci. Therefore, it is possible to distinguish between individuals.

Practical issues (e.g., small amounts of DNA) can limit the ability to obtain results; additionally, not all laboratories routinely type the 13 STR loci required for the national DNA database. Nonetheless, it is still possible to distinguish between individuals.

For more information on practical issues affecting DNA evidence see Module 3.

Historical Perspective of DNA Evidence Interpretation

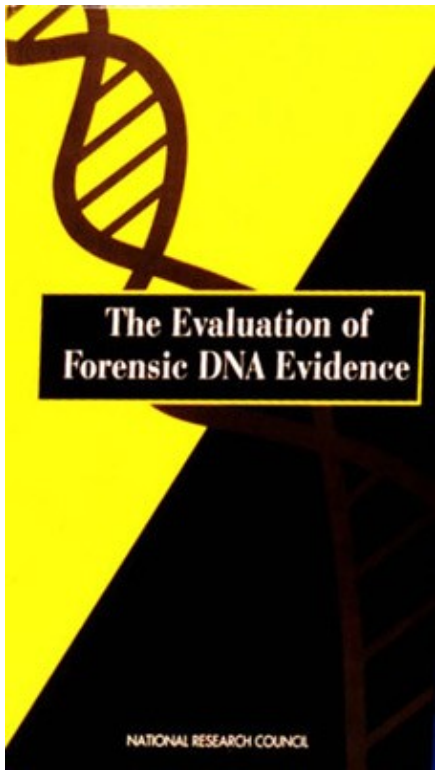


The National Research Council (NRC) of the National Academy of Sciences published a report in 1992, *DNA Technology in Forensic Science* (NRC I), that made several recommendations regarding analysis and interpretation of forensic DNA evidence. Access NRC I at http://www.nap.edu/books/0309045878/html.

At that time, restriction fragment length polymorphism (RFLP) technologies were most commonly used for forensic DNA analysis. The NRC committee concluded that RFLP forensic DNA analysis methods were reliable and that even a 3- or 4-locus RFLP "match" was considered a rare event.

Continued

Historical Perspective of DNA Evidence Interpretation (cont.)



In response to evolving DNA technologies, as well as to scientific criticism of some of the conclusions drawn in NRC I, the National Academy of Sciences convened another committee to conduct a review of the 1992 report. A second NRC report, *The Evaluation of Forensic DNA Evidence* (NRC II) was published in 1996 and made further conclusions and recommendations regarding laboratory and statistical interpretation of DNA evidence. Access NRC II at http://www.nap.edu/books/0309053951/html/index.html.

Continued

Historical Perspective of DNA Evidence Interpretation(cont.)

The DNA Identification Act of 1994 required appointment of the DNA Advisory Board (DAB), which established the National Quality Assurance Standards (QAS), and endorsed the use of the statistical methods outlined in the NRC II report. Access the QAS website at http://www.fbi.gov/hq/lab/codis/qualassur.htm.

After DAB concluded its mission in 2000, the Scientific Working Group on DNA Analysis Methods (SWGDAM) became the entity tasked with recommending revisions to QAS.

For more information on quality assurance see Module 5.

Click here to view SEC. 210303, Quality Assurance and Proficiency Testing Standards, of the DNA Identification Act of 1994.

Click here to view the Quality Assurance Standards for Convicted Offender DNA Databasing Laboratories.

Statistical Interpretation of the Match

Many courts require statistical interpretation of a DNA match. Random match probabilities are most often used to interpret evidence from single source samples.

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.

Statistical Calculations

Once a DNA match is observed, forensic scientists estimate the chance of finding that DNA profile in particular human populations. This calculation is necessary to inform the jury of the rarity of the profile.

Individuals can often be distinguished from one another at even a single locus because 8-20 alleles have been observed in representative populations at each of the 13 STR loci.

Statistical Calculations and Source Attribution

Once an individual's 13-locus STR 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.

Based on individual laboratory policy, the report may include a statement of source attribution in addition to, or in place of, a statistical estimate.

Online Link - Click here to view the *Forensic Science Communications* article, - Source Attribution of a Forensic DNA Profile."

Online Link - Click here to view the *Forensic Science Communications* article, - Genetics Issues Affecting the Evaluation of the Frequency of Occurrence of DNA Profiles Calculated From Pertinent Population Database(s)."

Online Link - Click here to view information on uniqueness contained in the NRC II report.

Probability

The term "probability" refers to the chance of a particular event occurring. For example, the probability of observing a head in a coin toss would be one out of two, or one-half.

Probability and Population Databases

Population databases of major racial and ethnic groups are used to determine estimates of the rarity of DNA profiles. These databases sometimes consist of as few as 100 profiles from unrelated persons, yet allow a reliable estimate of the chance of observing a given DNA profile in a larger population.

STR Allele Frequencies

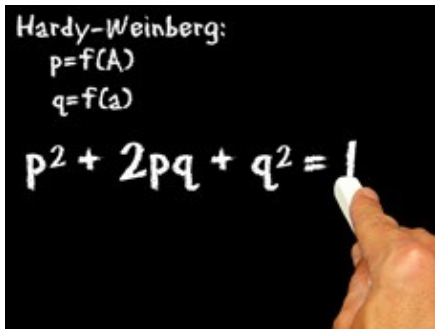
The DNA profiles of randomly selected people are used to determine allele frequencies in larger human populations. These allele frequencies are published as population data and used to estimate the frequency of genotypes in defined population groups.

Estimating STR Profile Frequencies - Independence

The alleles must be shown to be independent of one another, thereby allowing the use of the product rule to estimate an STR profile frequency.

The online version of this course contains a multimedia [or downloadable] file. Visit this URL to view the file: http://beta.forensic.dna.devis.com/module7/3/007

Estimating STR Profile Frequencies - The Product Rule



The product rule is used to estimate the chance of finding a given STR profile within a population. This is done by multiplying the frequency of each of the genotypes (combination of alleles) found at all loci in the STR profile.

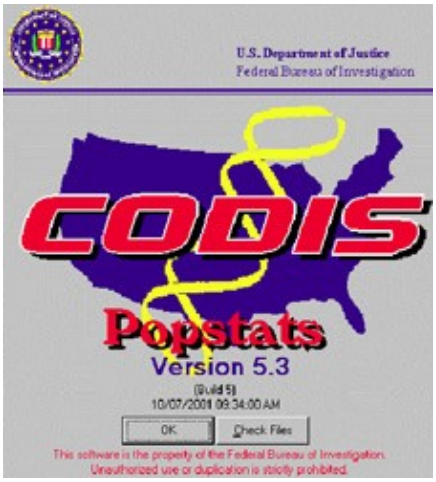
In the case of Y-chromosome STRs and mitochondrial DNA (mtDNA) the product rule can not be used. For more information on Y-STRs and mtDNA, refer to Module 8.

The product rule requires using formulas defined by "Hardy-Weinberg Equilibrium," which predicts the probability of observing a particular homozygote (same allele inherited from each parent) profile or a heterozygote (different allele inherited from each parent) profile in a population.

Online Link - Click here to view information on Hardy-Weinberg proportions contained in the NRC II report.

Click here to view an example of how the product rule is used.

Estimating STR Profile Frequencies - Statistical Software



Forensic laboratories typically use PopStats (supplied by the Federal Bureau of Investigation as part of CODIS) or other software to perform the statistical DNA match estimates. These software packages contain the necessary formulas to compute random match probabilities from published allele frequency data.

Estimating STR Profile Frequencies - Population Groups

Laboratories typically provide STR profile frequency estimates in three to four population groups. The reason for this is to provide a range of estimates from which to conclude the significance of matching DNA profiles.

For a discussion of the use of multiple population group statistical evidence, see *People* v. *Wilson* (11/16/04) Cal. Ct. App., A101459, 2004 Cal. App. Lexis 1918; *People* v. *Pizarro* Cal. App. 110 Cal. App. 4th 530 (2003).

Estimating STR Profile Frequencies - Special Circumstances

Two special circumstances require alternative approaches to the estimation of STR profile frequencies:

- Cases involving remote geographic regions with small population sizes. Access information contained in NRC II on calculating allele frequencies in small populations at http://www.nap.edu/books/0309053951/html/114.html
- Cases involving relatives

Click here to view additional information on familial considerations affecting the interpretation of forensic DNA evidence.

Interpreting Mixtures

Mixtures of DNA are commonly encountered in forensic science. The most common type involves the contribution of biological material by two individuals from intimate samples often encountered in sexual assault investigations. This occurs when the differential extraction of sperm from other cellular material (non-sperm) is not complete.

Continued

Interpreting Mixtures (cont.)

DNA mixtures can also occur if more than two individuals cannot be excluded as contributors. In some cases, a major contributor and a minor contributor can be established.

Continued

Interpreting Mixtures (cont.)

The interpretation of mixed samples requires the DNA analyst to consider several points:

- The amount of DNA sample amplified
- The number of STR loci that provide useful information
- The possible number of contributors
- Specific case information that may help to establish possible contributors
- The relative contribution of each possible source

Approaches to Mixture Interpretation

Once biological interpretations have been made, statistical weight is often provided for the sample depending on laboratory policy. Several approaches to perform the calculations exist within the forensic DNA community.

These approaches depend on the biological interpretation and facts of each case. The DAB statistics committee discussed several of these methods.

Online Link - Click here to view the *Forensic Science Communications* article - Statistical and Population Genetics Issues Affecting the Evaluation of the Frequency of Occurrence of DNA Profiles Calculated From Pertinent Population Database.

Mixture Laboratory Reporting

Laboratories may vary in the way in which they report mixtures:

- Report the presence of a mixed sample, without an accompanying statistical weight calculation
- Report the presence of a mixed sample and calculate a random match probability (e.g., when a major contributor can be clearly interpreted)
- Report the presence of a mixture and calculate the combined probability of inclusion (such as a random match probability) or a combined probability of exclusion
- Report the presence of a mixed sample and calculate the likelihood ratio of the known contributors to the mixed sample to the unknown contributors to the mixture

Continued

Mixture Laboratory Reporting (cont.)

While most laboratories now provide some kind of statistical calculation to a mixed sample, it is possible that the laboratory may not base results on the specific circumstances of the case. One appellate court in Michigan held that a DNA mixture was not admissible without accompanying statistical evidence.

Reporting a Mixture Without a Statistical Interpretation

In *Coy*, the laboratory identified a DNA mixture on a doorknob and a knife that could have come from both the victim and the suspect; however, no statistical estimates were provided for the sample.

The court held the following: "We find the instant evidence of a potential match between the defendant's DNA and the mixed samples to possess minimal probative value absent accompanying interpretive statistical analysis evidence... The significant possibility exists that the jury might have attributed the potential DNA match preemptive or undue weight, thus unfairly prejudicing defendant."

Calculation of Random Match Probability for Mixed Samples

Random match probability can be calculated in mixtures that involve two contributors and one contributor is known. For example, in sexual assault cases a vaginal swab is analyzed for the presence of semen and a DNA profile is developed from the sperm fraction and non-sperm fractions.

In some cases, as mentioned above, the sperm fraction results in a mixed sample that is consistent with the victim and the sperm donor. If the mixture reveals four alleles - 14, 15, 16, and 17 - and the victim is known to contribute the 14 and 15 alleles, it can be inferred that the sperm donor must be responsible for the 16 and 17 alleles.

Continued

Calculation of Random Match Probability for Mixed Samples (cont.)

The probability for this locus can be calculated in the same way as for a single source sample via the random match probability. Using the same approach, the additional loci will be evaluated.

A typical statement would be the following: The probability of randomly selecting an unrelated individual from the U.S. population who could not be excluded as a contributor to the mixed sample is estimated to be 1 in 2 million.*

** This number used arbitrarily for this example.*

Probability of Exclusion

Probability of Exclusion is a calculation that can be useful when interpreting complex mixtures. This approach does not assume the possible number of contributors or the identity of any single contributor.

The probability of exclusion is a conservative estimate because it includes *all* possible genotypic combinations based on the alleles identified in the mixed sample.

Continued

Probability of Exclusion (cont.)

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%.

Likelihood Ratio Estimates

Likelihood ratio estimates compare the probability of observing a profile if known contributors were the source of the DNA in a mixture (numerator) to the probability of observing the mixed profile if other unknown contributors were the source of the DNA (denominator).

This approach is flexible and can handle differing assumptions as to the possible contributors to a mixed DNA profile. Conclusions are often stated in the following manner: It is 2 million* times more likely that the DNA profile from the mixed stain originated from the victim and suspect rather than two unknown contributors.

** This number used arbitrarily for this example.*

Module Objectives Review

If you have successfully completed Module 7, you should be able to:

- Understand why statistical estimates are provided for forensic DNA evidence
- Understand the concepts relating to determination of allele frequencies in human populations and how they relate to DNA profile frequency estimates
- Understand special considerations affecting the interpretation of DNA evidence

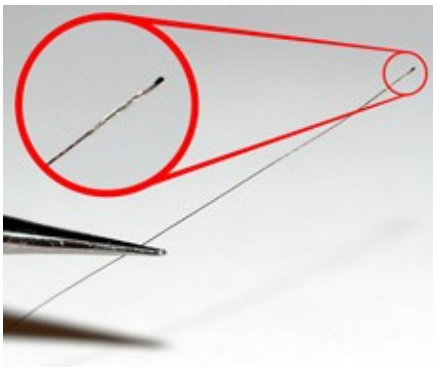
You have successfully completed Module 7, Statistics and Population Genetics. Proceed to Module 8, Mitochondrial DNA & Y-STR Analysis.

Module Objectives

Upon completion of Module 8, you will be able to:

- Identify the characteristics of mitochondrial DNA (mtDNA) and how it relates to nuclear DNA.
- Understand the significance of mtDNA laboratory analysis and potential reportable outcomes.
- Recognize scientific and legal issues that affect use of mtDNA laboratory analysis results.
- Understand the significance and appropriate use of Y-STR analysis.

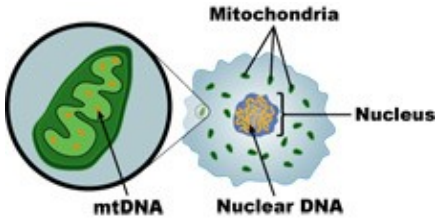
Mitochondrial DNA



Mitochondrial DNA (mtDNA) analysis is useful in forensic cases in which nuclear DNA is insufficient for short tandem repeat (STR) typing. Shed body, head, and pubic hairs with no cellular material (hair follicle) attached to the root bulb and aged skeletal remains are the samples most commonly analyzed for mtDNA because nuclear DNA is not recoverable from these tissues.

Continued

Mitochondrial DNA (cont.)



mtDNA is located in a small cellular structure called a mitochondrion, which produces energy for the cell. There are hundreds to thousands of mitochondria per cell, and each mitochondrion contains 1-10 mtDNA molecules. The high copy number of mtDNA molecules is one reason why mtDNA is recoverable from hairs and old skeletal remains.

The online version of this course contains a multimedia [or downloadable] file. Visit this URL to view the file: http://beta.forensic.dna.devis.com/module8/1/003

Maternal Inheritance Pattern

One unique characteristic of mtDNA is that it is passed from a mother to her children. A man's mtDNA is inherited from his mother, but he does not pass it on to his children. This maternal inheritance pattern has two important implications in forensic testing.

Click here to view an animation demonstrating how mitochondrial DNA is inherited.

Continued

Maternal Inheritance Pattern (cont.)

The first implication is an advantage: the mtDNA of only a single maternal relative, even distantly related, can be compared to the mtDNA from skeletal remains believed to be from a missing person. Another example would involve comparisons between maternal relatives and crime scene samples in a "no-body" homicide.

Continued

Maternal Inheritance Pattern (cont.)

The second implication is a disadvantage: mtDNA is not a unique identifier. Because maternal relatives share the same mtDNA type, the source of a biological sample can never be conclusively identified with mtDNA. mtDNA analysis is a test of exclusion - that is, can someone be excluded as the source of a questioned sample?

Hypervariable Regions

The role of nucleotides in mtDNA is to code for genes involved in energy production. However, there are two small, noncoding hypervariable regions that contain DNA information used in forensic testing. The mtDNA type of a biological sample is determined by the precise order, or sequence, of the DNA nucleotides in these regions.

Click here to view an animation on Hypervariable Regions.

Continued

Hypervariable Regions (cont.)

In the 1980s, scientists discovered that the probability of randomly selecting two people with the same mtDNA type was very low because there are thousands of mtDNA types among humans. Of the 700 nucleotides in the hypervariable regions, two maternally unrelated people have about 10 nucleotide differences.

mtDNA Analysis

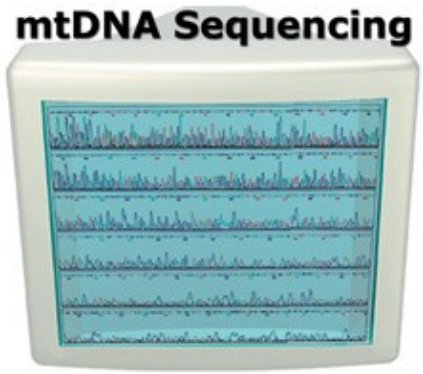
An mtDNA laboratory analysis is both similar to and different from an STR analysis.

The first two steps are the same:

- Extraction: Isolates DNA from all other material in the sample
- Polymerase chain reaction (PCR) amplification: Targets the two mtDNA hypervariable regions to make millions of copies for subsequent analysis

Continued

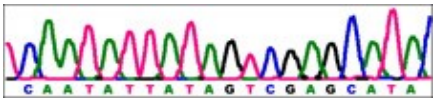
Sequencing



The third step in mtDNA analysis is different:

- Sequencing: Dideoxy sequencing, a well-established technique that originated in 1977, places fluorescent chemical tags on the terminal nucleotides of DNA fragments that differ in length by a single nucleotide. When these fragments are electrophoresed through a sequence detection instrument, a laser excites each fluorescent tag as it passes by. A camera detects the emitted fluorescence and "reads" the sequence or order of the DNA nucleotides.

DNA Sequences



DNA sequences are visualized in an electropherogram. Colored peaks are labeled "A," "C," "G," "T," and occasionally "N" (when the sequence detection instrument cannot designate a specific nucleotide). In a typical mtDNA analysis, about 700 nucleotides are analyzed for each sample. The electropherogram can be seen on a computer screen or printed out on paper.

Continued

DNA Sequences (cont.)

DNA sequences collected by the sequence detection instrument are imported into a computer program so that two DNA examiners can check their quality. If the electropherogram data from all samples are of acceptable quality, mtDNA sequences from different case samples are compared to determine whether two samples could have shared a common source.

Reportable Outcomes

An mtDNA analysis has two primary reportable outcomes:

- Failure to exclude: "The mtDNA sequences of hair sample A and person B share a common nucleotide at all positions. Therefore, person B and his/her maternal relatives cannot be excluded as the contributor of hair sample A." In this outcome, a statistical context for the failure to exclude is provided.
- Exclusion: "The mtDNA sequences of hair sample A and person B are different. Therefore, person B and his/her maternal relatives are excluded as the contributor of hair sample A." Because a single nucleotide mutation can occur within a person, at least two nucleotide differences must be observed for an exclusion.

In both cases, the report accounts for the fact that person B's maternal relatives have the same mtDNA type as person B.

Continued

Reportable Outcomes (cont.)

The following additional outcomes may be reported, although these are much more infrequent:

- No results: "Insufficient mtDNA was obtained from hair sample A to obtain a profile."
- Inconclusive: "The mtDNA sequences of hair sample A and person B differ at a single nucleotide position. Therefore, person B and his/her maternal relatives can be neither included nor excluded as the contributor of hair sample A."

Continued

Reportable Outcomes (cont.)

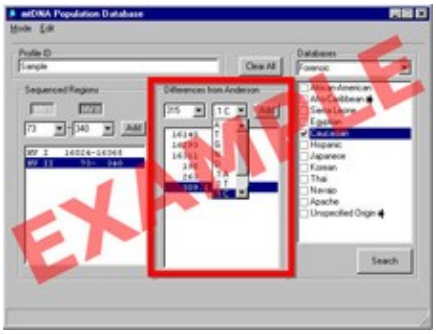
An inconclusive result could occur even if a sample (most commonly a hair) has actually come from the known person to whom it is compared. This is because a mutational change might have occurred during the lifetime of a single hair to yield an mtDNA sequence that is one nucleotide different from the other hairs, blood, or cheek cells from that person. Although an inconclusive interpretation could result in a false exclusion, it cannot result in a false failure to exclude. Fortunately, inconclusive outcomes are rare.

Data Presentation

An mtDNA report is similar to an STR report. One exception is the format of data presentation if a laboratory chooses to report the DNA sequence data in a tabular form. An mtDNA data table shows the nucleotides in the analyzed samples that are different from those of a published standard mtDNA reference sequence (termed the Anderson sequence or *Cambridge Reference Sequence [CRS]*). All other nucleotides, of the 700 or so that are analyzed, match the CRS and are not shown in the table. The CRS provides both a benchmark and a shorthand method for comparing multiple samples in a case.

For more information on laboratory reports, see Module 6.

Relevance of Statistical Information



A statistical calculation appropriate for mtDNA analysis gives a meaningful context for the failure to exclude a maternal lineage as the source of a sample.

First, an mtDNA sequence database that is assembled and maintained by the Federal Bureau of Investigation is searched for the mtDNA type observed in a case. A computerized search output states how many times that type is in the database. This is the *database frequency*.

Online Link - Click here to view the *Forensic Science Communications* article, "The mtDNA Population Database: An Integrated Software and Database Resource for Forensic Comparison."

Click here to read more about mtDNA statistical reporting.

Continued

Relevance of Statistical Information (cont.)

Second, an estimate of the frequency in the general population is calculated by plugging the database frequency into a sampling equation. An example of a conclusion derived from this calculation is, "The mitochondrial DNA profile observed in hair sample A and individual B would not be present in at least 99.94% of North Americans (with 95% confidence)."

A related conclusion is, "The mitochondrial DNA profile observed in hair sample A and individual B would be present in no more than 0.06% of North Americans (with 95% confidence)."

Contamination

The prevention and detection of laboratory contamination, specifically the introduction of exogenous mtDNA into the testing process, is given special attention in mtDNA testing because of the natural abundance (high copy number) of mtDNA. Prevention methods include:

- Separation of pre- and post-PCR processing.
- Dedicated reagents for extraction and PCR.
- Ultraviolet light and bleach to destroy DNA on surfaces.
- Lab coats, gloves, face masks, and other disposables.

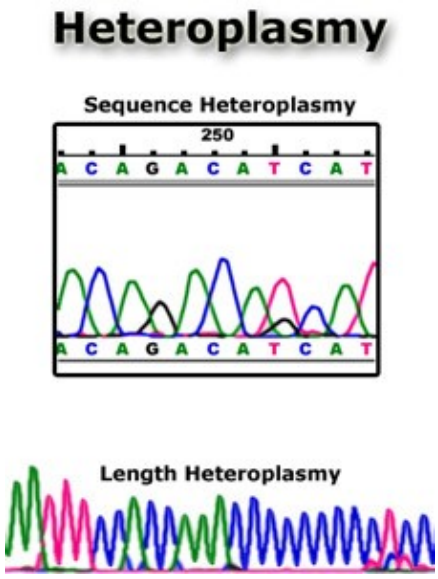
The most important detection tools are negative controls that accompany all samples through testing and should remain free of mtDNA.

Continued

Contamination (cont.)

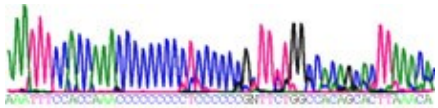
Forensic mtDNA analysis can tolerate minimal contamination, and the likelihood that it will occur in a small percentage of cases is acknowledged in the scientific literature. Laboratories must develop validated guidelines for data interpretation in the presence of contamination.

Heteroplasmy



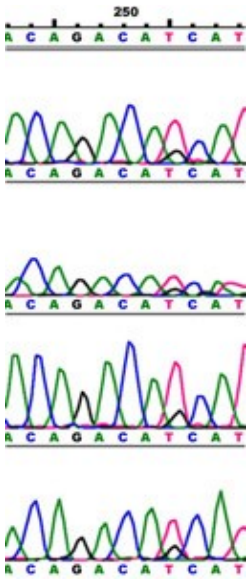
Heteroplasmy is defined as the presence of more than one mtDNA type within a single individual. Heteroplasmy was originally believed to be rare among healthy individuals, but scientists now believe that each person has some low- frequency, slightly different mtDNA types mixed in with his or her inherited dominant type. These low-frequency types arise from mtDNA mutations within growing and dividing cells. The two types of heteroplasmy are length heteroplasmy and sequence (or site) heteroplasmy.

Length Heteroplasmy



Length heteroplasmy is the presence of mtDNA molecules that differ in length. Extremely common, it most often appears in the electropherogram as varying numbers of Cs in certain well-known areas of the hypervariable regions. Its presence may be noted but does not usually play a role in interpretation. This is because even within an individual there may be very diverse length variants.

Sequence (Site) Heteroplasmy



Sequence (site) heteroplasmy is the presence of mtDNA molecules that have different nucleotides at the same address. For example, an electropherogram from a heteroplasmic hair might show both T and C at position 16,093. In a blood sample from the same individual, position 16,093 could show *T or* C, or T *and* C. A failure to exclude would be scientifically supported if the blood had any of these three possibilities, because the blood and hair share a common base at every position, including the heteroplasmic position.

If T *and* C are present in *both* hair and blood, the failure to exclude is actually strengthened because the heteroplasmy is in both samples.

Continued

Sequence (Site) Heteroplasmy (cont.)

Sequence heteroplasmy, the presence of mtDNA molecules that differ by a single DNA base, is observed in about 10% of hairs and in about 1% of blood samples. The higher frequency in hairs is due to the development of a hair from only a few stem cells. Certain nucleotide sites are well-recognized mutational hot spots, that is, DNA locations where sequence heteroplasmy is likely to be observed.

Population Statistics

Dozens of scientific papers published since 1981 describe worldwide mtDNA variation. In most continental, national, or regional databases, it is characteristic to observe many rare types with frequencies well below 1% and a few common types with frequencies exceeding 1%. For example, one type is present in about 4% of North Americans. A few other common types have frequencies of less than 3%.

Exceptions to this overall high diversity are Native Americans, African Pygmies, and other groups that tend to be anthropologically interesting because of their geographic isolation. Most have had small population sizes in recent history that limited or reduced their genetic diversity, including their mtDNA variation.

Online Link - Click here to open the "MITOMAP" human mitochondrial genome database website.

Courtroom Admissibility

Forensic mtDNA analysis has been admitted for trial in at least half of the United States since its introduction in a child homicide case in Tennessee in 1996 and continues to undergo *Frye* and *Daubert* hearings in some jurisdictions.

For more information on cases involving an mtDNA admissibility ruling see Module 11.

Online Link: Click here to view the complete texts of some written court decisions.

Interesting Uses of mtDNA

The use of mtDNA as a forensic tool evolved from its role in the study of human history and human disease. mtDNA analysis solved several historical mysteries, such as the identification of the Czar's remains in Russia and the skeleton of Jesse James. Anthropologists have recovered mtDNA from Neanderthal skeletons at least 30,000 years old.

This type of forensic analysis routinely aids in identification of war dead, including a serviceman who served in Vietnam now buried in the Tomb of the Unknown Soldier. Recently, it augmented STR testing of remains from the World Trade Center attacks (9/11/01).

Topic 4 : Y-STR Laboratory Analysis

The Y chromosome is found only in males and is inherited in a patrilineal fashion (i.e., from father to son). STR genetic markers present on this chromosome may be used to obtain the genetic profile of the male donor(s) in mixtures of body fluids from males and females.

Click here to view an animation demonstrating Y-STR inheritance.

Indications for Y-STR Analysis

Typically in such mixture cases, the standard autosomal STR analysis has failed to determine the DNA profile of the male donor(s) or it has not been attempted due to the intractability of the particular mixed sample to such analysis. A good example of a case that would benefit from a Y-STR analysis would be the fingernail scrapings from a female victim who had scratched her male assailant.

Continued

Indications for Y-STR Analysis (cont.)

Often the male component comprises a tiny fraction of the DNA recovered from fingernails with most of the DNA originating from the victim herself. Also, unlike mixtures of sperm and non-sperm cells, it is not possible to perform a differential extraction procedure to subfractionate and purify the DNA further into its constituent male and female components. The inability to obtain a standard (autosomal) STR profile from the male, despite the presence of male cells, is the result. However, Y chromosome analysis may yield the genetic profile of the perpetrator due to the ability of the system to ignore the overwhelming quantities of female DNA present.

Continued

Indications for Y-STR Analysis (cont.)

Other mixture cases in which Y-STR analysis may be useful include sexual assaults involving saliva/saliva and saliva/vaginal secretion mixtures and instances in which the post-coital interval between the incident and the collection of intimate samples from the victim is greater than 2 days.

Specialized Circumstances Involving Y-STR Analysis

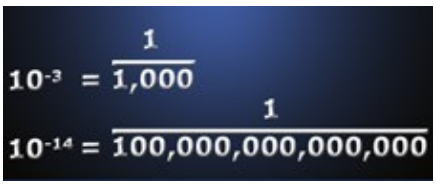
There may be additional specialized circumstances in which a laboratory may deem Y-STR analysis to be appropriate:

1. In sexual assaults, to obviate the need for the time-consuming and oft-times inefficient differential extraction procedure for the separation of sperm and non-sperm fractions.
2. To determine the number of semen donors in rape cases involving multiple assailants.
3. In criminal paternity Y-STR haplotype of a missing individual by typing a male relative such as a son, brother, father, uncle, or nephew.
4. To provide increased statistical discrimination in mixture or kinship analysis cases in which the likelihood ratio obtained from autosomal markers is insufficient for identification purposes.

Haplotypes

Y-STR loci, unlike autosomal STR markers, are not independent of one another due to the lack of recombination along most of the chromosome's length and are co-inherited as extended haplotypes of linked markers. The estimation of the frequency of occurrence of a particular haplotype therefore necessitates the use of a counting method, which is entirely dependent on the size of the database. This is similar to the situation with mtDNA testing.

Y-STR Statistical Analysis



As a result of these factors, the degree of inter-individual Y-chromosome variation is substantially reduced compared to the autosomes.

- A typical autosomal STR profile may have an expected frequency of occurence in 1 in every 100 trillion individuals (10^{-14}), whereas a typical Y- STR profile may occur in 1 in every 1000 individuals (10^{-3}).

Y-STR Analysis Kits

In the United States a set of 10 core Y-STR markers is used: DYS19, DYS385, DYS389I, DYS389II, DYS390, DYS391, DYS392, DYS393, DYS438, and DYS439.

All commercial manufacturers of Y-STR kits employ these markers and some have added additional markers for increased discrimination.

Y-STR Profiles

It is important to note that, unlike the situation with autosomal STRs, it is not possible to distinguish fathers, sons, and brothers because, barring rare mutations, they all possess the same Y-STR profile. Some laboratories will emphasize this by including a statement to that effect in their reports.

Module Objectives Review

If you have successfully completed Module 8, you should be able to:

- Identify the characteristics of mtDNA and how it relates to nuclear DNA.
- Understand the significance of mtDNA laboratory analysis and potential reportable outcomes.
- Recognize scientific and legal issues that affect use of mtDNA laboratory analysis results.
- Understand the significance and appropriate use of Y-STR analysis.

You have successfully completed Module 8, Mitochondrial DNA & Y-STR Analysis. Proceed to Module 9, Forensic DNA Databases.

Click "Forward" to p

Module Objectives

Upon completion of Module 9, you will be able to:

- Understand forensic DNA databases.
- Recognize how DNA databases can be used to investigate crime.

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.

The Federal DNA Identification Act was enacted as part of the Violent Crime Control and Law Enforcement Act of 1995 (Public Law No. 103-322). That law authorized the FBI to establish a National DNA index for law enforcement. Since then, the Federal and State governments have invested significant resources toward developing a National database system.

Online Link - Click here to access information about CODIS at http://www.fbi.gov/hq/lab/codis/index1.htm

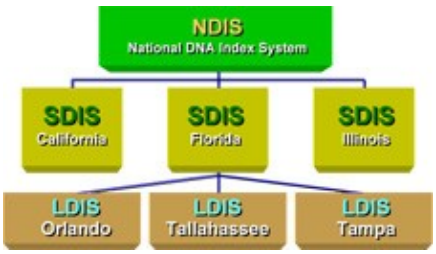
CODIS Indexes

CODIS uses two main indexes: The Forensic Index and the Offender Index .

The Forensic Index contains DNA profiles from crime scene evidence.

The Offender Index contains DNA profiles of individuals who have been convicted of various offenses defined by State and/or Federal law.

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)

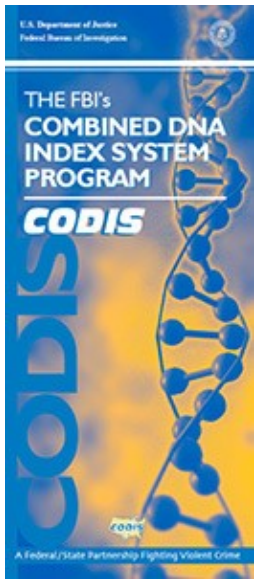
CODIS Data Collection

CODIS software enables local laboratories (LDIS) to feed DNA data electronically to SDIS, which is operated by a designated State laboratory. SDIS allows local laboratories in the same State to exchange DNA profiles.

Local laboratories cannot upload DNA profiles directly into NDIS. Instead, each State's CODIS laboratory has an administrator who is responsible for maintaining the data and information in SDIS. The State laboratory then inputs data into NDIS, which also receives DNA profiles analyzed by the FBI Laboratory. NDIS became fully operational in October 1998. As of May 2005, NDIS contained nearly 2.5 million DNA profiles.

Online Link - Click here to access the FBI Laboratory's web page.

CODIS and the FBI



The FBI provides free CODIS software, installation, training, and user support to any State or local law enforcement laboratory that performs DNA analysis.

The three-tiered system allows State and local agencies to operate their individual databases within the confines of State laws, which vary from jurisdiction to jurisdiction.

NDIS

States that participate in CODIS submit their data to NDIS, which is administered by the FBI. The FBI plays an active role in ensuring the quality of the results in NDIS. The exchange of information within this secure system is controlled by and strictly limited to law enforcement.

Standards

The DNA Identification Act of 1994, which established NDIS, also created a DNA Advisory Board (DAB) to develop and revise recommended standards for quality assurance. The board's recommendations ultimately resulted in *Standards for Forensic DNA Testing Labs* and *Standards for Convicted Offender Labs* issued by the Director of the FBI.

To participate in NDIS, States must sign a memorandum of understanding verifying that the submitting laboratory is in compliance with the FBI's quality assurance standards.

Click here to view the *Standards for Forensic DNA Testing Labs.*

Click here to view the *Standards for Convicted Offender Laboratories.*

CODIS Hits

When CODIS software recognizes the same DNA profile in the Forensic or Offender Index, it identifies the two profiles as a match. These matches are commonly referred to as "hits."

After CODIS software produces a hit, qualified laboratory personnel analyze the DNA samples to either validate or refute the match. This is usually done as a precautionary measure to make sure there are no problems with data entry. There are times, however, when the DNA profile found on crime scene evidence is a mixture of more than one person's DNA. In that case, analysts must compare profiles to see if the offender's profile is part of the mixed DNA.

Forensic Index Hits

When a DNA profile in the Forensic Index matches another profile in the Forensic Index, crime scenes can be linked together. These hits enable investigators to identify serial offenders, coordinate investigations, and share leads, even across multiple jurisdictions.

Offender Index Hits

When a profile in the Forensic Index matches a profile in the Offender Index, the hit may reveal the identity of the perpetrator or another person who was present at the crime scene. This type of hit is normally used as

probable cause to get a new biological sample from the offender to retest against the crime scene evidence. The second sample is taken for analysis within the prosecuting jurisdiction.

Other DNA Indexes

In addition to the Forensic Index and the Offender Index, CODIS also contains a Population Index and a Missing Persons Index.

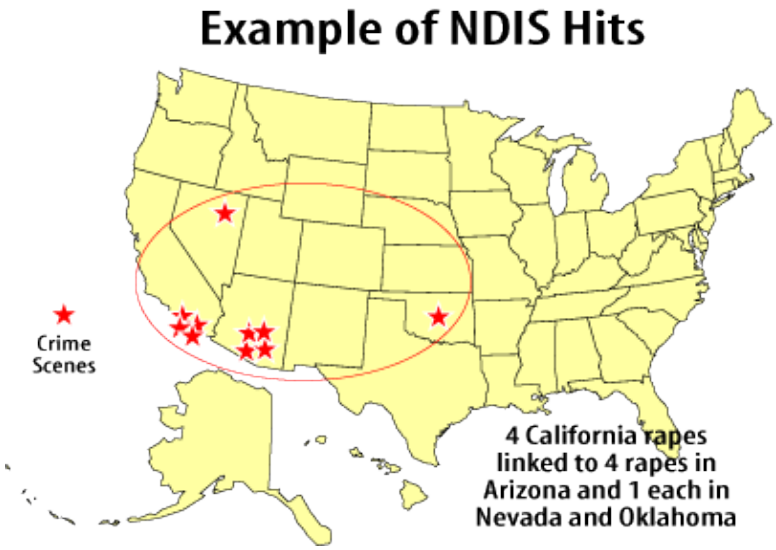
The Population Index contains allele frequency data and DNA profiles from anonymous people. This index is used to estimate statistical probabilities of DNA profiles within major population groups.

The Missing Persons Index contains DNA profiles from unidentified human remains as well as the known relatives of missing people. The index is used to identify remains and to bring resolution to their cases.

Other databases exist or are being developed, such as a mitochondrial DNA (mtDNA) index.

Using DNA Databases To Investigate Crimes

The utility of the database system to investigate and solve crime is directly dependent on the number of DNA profiles contained in the Offender and Forensic Indexes.



Legislative Guidelines

The FBI Laboratory has issued legislative guidelines recommending provisions to be included in State database laws. The guidelines include provisions regarding access, disclosure, compatibility, expunction, and penalties for unauthorized disclosure.

State Statutes and DNA Databasing

All 50 states, the District of Columbia, and all Federal jurisdictions now require certain classes of convicted offenders to provide a biological sample for DNA databasing. Each jurisdiction's statute determines whether a person convicted of an offense will be required to submit a biological sample for DNA databasing.

Continued

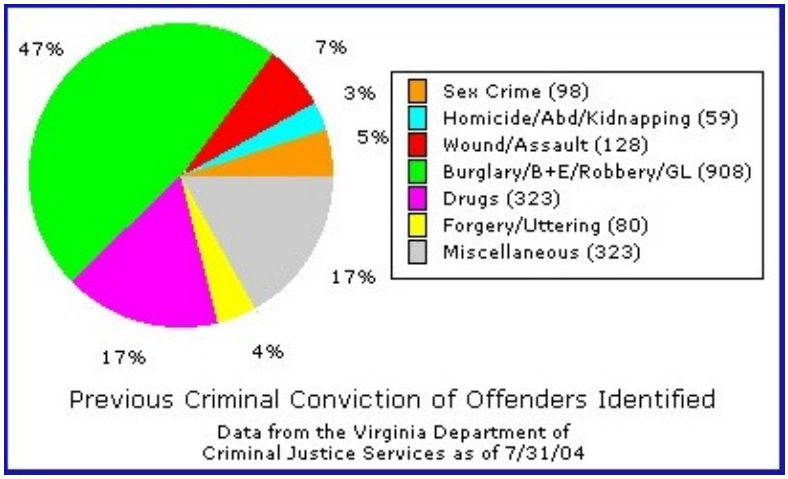
State Statutes and DNA Databasing (cont.)

State DNA databasing statutes vary widely from jurisdiction to jurisdiction. Some States are more restrictive, but the majority of States authorize the inclusion of DNA profiles from all convicted felons, other States require anyone convicted of a qualifying offense to submit a DNA sample, and still others require samples from persons *arrested* for a qualifying offense. However, not all samples collected under state statutes can be

included in NDIS.

Comprehensive DNA Databases

Comprehensive databases that include profiles of offenders who commit lesser offenses, such as property crimes, can be extremely valuable.



DNA Analysis Backlog

Using DNA databases to solve cases depends on the number of cases submitted and the laboratories' capacity to analyze biological evidence. Backlogs of unanalyzed cases exist in both law enforcement agencies and laboratories due to limited resources.

Module Objectives Overview

If you have successfully completed Module 9, you should be able to:

- Understand forensic DNA databases
- Recognize how DNA databases can be used to investigate crime

You have successfully completed Module 9, Forensic DNA Databases. Proceed to Module 10, Collection of DNA Evidence from Suspects and Arrestees.

Module Objectives

Upon completion of Module 10, you will be able to:

- Understand how a suspect's DNA is obtained.
- Recognize key legal issues surrounding the collection of DNA evidence.

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. 1
- By consent or from a sample left in a public place or crime scene.

Continued

DNA Collection in a Public Place

When an individual leaves a biological sample in a public place and it is subsequently collected, there is no invasion of the person's privacy and thus no Federal constitutional right is implicated. 2

Continued

DNA Collection in a Public Place (cont.)

As a general rule, however, 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. 3
- 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. 4

Constitutional Right to Counsel

There is no right to counsel until the criminal process has commenced. The right to counsel does not apply when police approach an individual who has not been arrested and ask for the person's consent to obtain DNA evidence.

Likewise, the right to counsel does not apply when an individual is arrested and the seizure of DNA evidence occurs before formal criminal proceedings are commenced.

Continued

Constitutional Right to Counsel (cont.)

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. Each of these issues is discussed in turn. 5

Probable Cause

The fourth amendment requires that police have *probable cause* before an individual is arrested. Before a person may be detained, police must have reasonable suspicion of criminal activity. 6

If neither of these legal standards is met, the seizure of DNA from a person who has been detained or arrested will be deemed unlawful if the DNA evidence is a "fruit" or product of the illegal seizure of that person.

Hayes v. Florida

When an individual is stopped by police upon reasonable suspicion of criminal activity, the question is whether police may secure a DNA sample, either at the scene of the stop or by briefly transporting the individual to a nearby police station, hospital, or other facility.

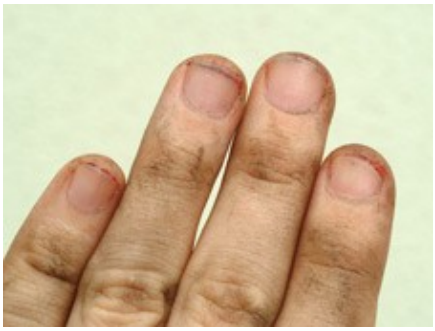
Continued

Hayes v. Florida (cont.)

Although there is no U.S. Supreme Court decision addressing the seizure of an individual's DNA, in *Hayes* v. *Florida,* the Court held it unconstitutional to remove a suspect to a police station for fingerprinting in the absence of probable cause or consent.

The *Hayes* decision affirmed an earlier holding in *Davis* v. *Mississippi*, which invalidated the police fingerprinting of an individual brought to the police station as a part of a dragnet operation searching for suspects. 7

Cupp v. Murphy



In another decision, *Cupp* v. *Murphy,* the Court allowed police to take fingernail scrapings from a suspect when there appeared to be a blood stain on/under the nail. The Court's reasoning focused in large part on "the very limited intrusion undertaken incident to the station house detention, and the ready destructibility of the evidence. . . " 8

Davis and Hayes

The Supreme Court's decisions in *Davis* and *Hayes* mention, but do not conclusively address, one potential exception to the rule that a person cannot be taken to the police station for fingerprinting without probable cause or the person's consent.

If a person is not arrested but is *legally* detained based on reasonable suspicion, it *may* be permissible to fingerprint that person at the scene at which he or she was stopped without securing a warrant. 9

Continued

Davis and Hayes (cont.)

Read together, *Hayes* and *Davis* stand for the following propositions:

- Just as with fingerprint evidence, if there is no probable cause to arrest a person, any DNA evidence obtained as a result of that seizure is unlawful.
- If police have lawfully detained a person (as in a traffic stop or brief pedestrian stop), it *may* be legal to take a DNA sample at the scene if it is not done in an unreasonably intrusive manner. It is unresolved as to whether a court order or warrant would be required.
- In the absence of probable cause or reasonable suspicion, there must be valid consent that was not tainted or polluted by an illegal arrest or detention.

Method of Obtaining the Known Sample

In some jurisdictions, a DNA sample is routinely taken from an arrestee in a process similar to booking and fingerprinting. In all cases, however, the method of obtaining a DNA sample must comply with constitutional requirements.

The U.S. Supreme Court has permitted police to seize, without a warrant, physical evidence from a lawfully arrested person. In *United States* v. *Edwards*, police were allowed to seize an arrestee?s clothing to look for paint chips that matched evidence at the crime scene. However, *Edwards* may be limited by two facts: There

was clear probable cause linking the clothing to the crime scene, and a search of clothing for paint chips is not a physically intrusive one. 10

Because this issue remains unresolved at this time, police or prosecutors may elect to obtain a court order or warrant to permit the obtaining of a DNA sample.

Obtaining an Evidentiary Sample From an Arrestee

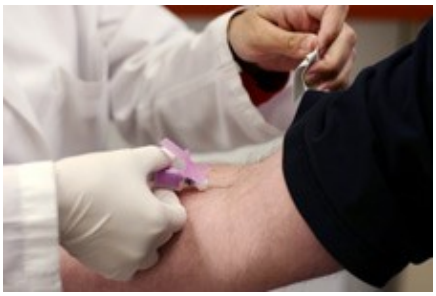
An arrested individual also may have evidentiary DNA evidence on his or her body or clothing. For example, fingernail scrapings may contain DNA from the victim. The method of collecting such a sample must comply with same constitutional requirements that apply to obtaining an arrestee's DNA sample.

If the evidence is *on* the suspect's clothing, or otherwise can be obtained without intruding into his/her body, it may be permissible to seize it without a warrant. 10 However, if the sample can be obtained only by bodily intrusion, a warrant is required, absent exigent circumstances. 11

To avoid a legal challenge, police may choose to secure a court order or warrant to ensure that the seizure of such evidence is constitutional. 12

Continued

Seizure of DNA



Whether conducted pursuant to a warrant, court order, or as part of routine processing, the nature of the intrusion to secure a biological sample must still be considered. In most cases, collecting blood, hair, or body swabs will not violate a person's constitutional rights, as it generally is not a substantially invasive procedure. 12

If a warrantless seizure of DNA is permitted, the same limits of intrusiveness apply.

Continued

Seizure of DNA (cont.)

When the intrusion is severe, such as a surgical procedure to remove a bullet, an individual's interest in bodily integrity may prevent such a search. The nature and severity of the intrusion and the threat to the individual's health must be balanced, on a case-by-case basis, with the government need for the evidence. 13

Consent

The alternative to obtaining a warrant is to secure a person's consent to giving a DNA sample. The principles governing consent are simple: The consent must be *voluntary*. 14

If there is an illegal arrest or detention, a subsequent consent will not be valid if it is the fruit of that illegality. Such consent may be valid, however, if there are intervening events (such as a consultation between the suspect and counsel) that attenuate the effect of the illegal arrest or detention. 15

Consent Need Not Be Written

There is no specific set of words or warnings needed to obtain a person's consent, and the Constitution does not require that the person be told of the right to refuse to consent.

As long as the person is not coerced and the scope of the search has been explained, consent will be deemed lawful. 16, 17

Click here to view a sample consent form.

Statutory Authorization for Collection of DNA Samples

Another method of obtaining DNA samples is in cases in which legislation authorizes or mandates the collection of DNA evidence from persons charged with or convicted of specified offenses.

Every Federal court of appeals that has considered the constitutionality of a statute compelling a convicted offender to provide DNA for databasing has upheld the law in question. 18

Continued

Statutory Authorization for Collection of DNA Samples (cont.)

Some States have statutes authorizing judges to issue nontestimonial orders, warrants requiring a nonarrested person to provide a DNA sample. Those warrants are issued upon a showing of probable cause that a crime has been committed and reasonable suspicion that the individual is a suspect in that case.

These statutes have been upheld by State courts. 19

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.

Continued

Retaining DNA Samples (cont.)

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, or 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 and may permit an arrest even if the statute of limitations has expired.

Probable Cause for an Arrest

Finding an individual's DNA evidence at a crime scene may not prove that the person was present at the time of the crime. To establish probable cause, additional facts are needed to link the DNA sample to the crime. Those additional facts may be found in the circumstances of the crime itself.

Indeed, courts have held that DNA evidence, without an identification by a live witness, is legally sufficient to convict (not merely to arrest). 20

Statutes of Limitations

Statutes of limitations vary from State to State and from crime to crime. The requirement is simple: a complaint, information, or indictment must be filed, identifying the perpetrator, before the period expires.

Continued

Statutes of Limitations (cont.)

When a crime occurs and the statute of limitations *in existence as of the date of commission* is thereafter statutorily expanded *before the original period expired,* prosecution may be initiated under the new, expanded (or telescoped) period of limitations.

In contrast, when the statute of limitations has expired for a particular crime, the statute may not be revived by legislation attempting to retroactively extend the period of limitation. 21

Continued

Statutes of Limitations (cont.)

To address the issue of statutes of limitations that prevent prosecution of crimes solved through DNA databases, some States have extended or eliminated statutes of limitations for crimes (such as sexual assault) that are likely to involve biological evidence.

John Doe Warrants

Some prosecutors have attempted to avoid the potential expiration of a statute of limitations by filing a "John Doe" warrant.

When DNA evidence is recovered and typed, it has a unique identifying character. If the DNA cannot be matched to a known individual (because no one has been arrested or the DNA does not match any profile in a database), there is no name to attach to the DNA.

Therefore, in a John Doe warrant, the suspect is identified by the suspect's unique DNA profile.

Continued

John Doe Warrants (cont.)

The analytical issue in John Doe cases flows from the historical purpose of the statute of limitations. The Supreme Court explained:

Statutes of limitations... represent a pervasive legislative judgment that it is unjust to fail to put the adversary on notice to defend within a specified period of time.... [T]hey protect defendants and the courts from having to deal with cases in which the search for truth may be seriously impaired by the loss of evidence, whether by death or disappearance of witnesses, fading memories, disappearance of documents, or otherwise.

Continued

John Doe Warrants (cont.)

The question courts will have to resolve is whether a DNA identification, or use of the names John or Jane Doe coupled with facts describing the criminal event, will "put the adversary on notice to defend within a specified period of time."

At least one State appellate court has approved a DNA identification "John Doe" warrant for statute of limitation purposes. 22

The Wisconsin decision in Dabney 22, suggests that such a warrant would be made stronger if it also included, where available, a physical description of the offender.

Click here to view an example of a John Doe warrant.

Continued

John Doe Warrants (cont.)

Alternative responses include legislation enlarging current statutes of limitations. The *Dabney* case notes that Wisconsin amended its statute of limitations to specifically permit prosecutions in cases in which DNA is recovered to commence up to 12 months after the DNA evidence is matched to a specific person.

Click here for more information regarding Wisconsin statutes.

Module Objectives Review

If you have successfully completed Module 10, you should be able to:

- Understand how a suspect's DNA is obtained.
- Recognize key legal issues surrounding the collection of DNA evidence.

You have successfully completed Module 10, Collection of DNA Evidence from Suspects and Arrestees. Proceed to Module 11, Pretrial DNA Issues.

Click "Forward" to p

Module Objectives

Upon completion of Module 11, you will be able to:

- Understand discovery issues involved with DNA evidence.
- Recognize pretrial legal questions related to DNA evidence.
- Have knowledge of specific discovery items requested in cases in which DNA testing occurs.

- Recognize issues important to defendants in criminal cases with potential DNA evidence.
- Recognize DNA-related issues for persons who plead guilty to, or are convicted of, criminal charges.

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.

Retention of Biological Evidence

Some States require that biological evidence in criminal cases be retained.

After a case involving biological evidence is resolved, prosecutors should ensure that the evidence is stored appropriately.

Basic Discovery: The Duty to Preserve

The Constitution does not require the police or prosecution to preserve all potential evidence. The critical distinction is between evidence that is materially relevant and evidence that is potentially useful. Police loss or destruction of potentially useful evidence (i.e., evidence that might prove exculpatory if tested) does not violate due process "unless a criminal defendant can show bad faith on the part of the police." 1 At the same time, loss of (or failure to disclose) material exculpatory evidence establishes a due process violation. 2

Continued

Basic Discovery: The Duty to Preserve (cont.)

The specific failure to preserve biological crime scene samples for DNA testing has been held not to violate due process principles in the absence of bad faith. The police must *know* before destruction that the evidence would in fact have exculpated the suspect/defendant.

> "[R]espondent has not shown that the police knew the semen samples would have exculpated him when they failed to perform certain tests or to refrigerate the boy's clothing; this evidence was simply an avenue of investigation that might have led in any number of directions. The presence or absence of bad faith by the police for purposes of the Due Process Clause must necessarily turn on the police's knowledge of the exculpatory value of the evidence at the time it was lost or destroyed." [3]

Continued

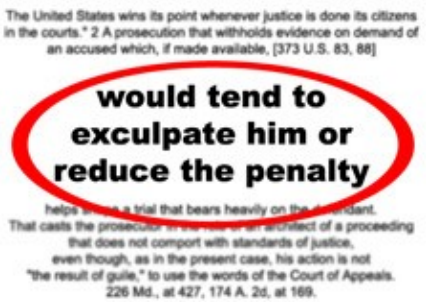
Basic Discovery: The Duty to Preserve (cont.)

Youngblood remains the governing *Federal* law today. [4] However, several States have applied a different standard, under their respective constitutions or criminal discovery statutes, and do not require proof of bad faith when contesting the destruction of potentially exculpatory evidence. [5] In some States, the focus is on the duty to preserve material evidence; others look at whether the evidence that was destroyed might have been

material and weigh its potential importance against the evidence used to convict.

Continued

Basic Discovery: The Duty to Disclose



Assuming that evidence has been retained (or retained and tested), the duty to disclose determines what must be released to the other party and when that release must occur. In cases in which evidence (the physical evidence and/or the test result) is exculpatory, disclosure of its existence is mandatory under the U.S. Constitution. 6 Evidence is exculpatory if it "would tend to exculpate him or reduce the penalty..." 7

Continued

Basic Discovery: The Duty to Disclose (cont.)

Discovery rules often provide for defense access to physical evidence, on request or by motion to the trial court. 8 Discovery rules generally mandate government disclosure of "reports of examination and tests" if either the prosecution intends to use those results or they are "material to preparing the defense..." 9

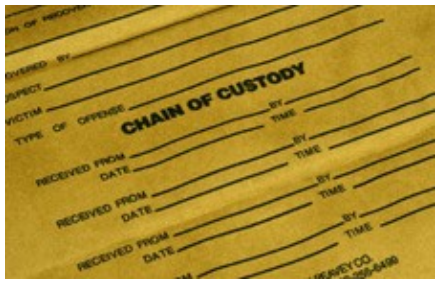
Continued

Basic Discovery: The Duty to Disclose (cont.)

Timing of disclosure varies among jurisdictions. Early disclosure can have the following benefits:

- Avoiding surprise and unnecessary delay.
- Identifying the need for defense expert services.
- Facilitating exoneration of the innocent and encouraging plea negotiations if DNA evidence confirms guilt.

Contents of a Discovery Request



Items subject to discovery can include:

- Chain of custody information, including all items recovered.
- Identification of the laboratory utilized.
- Qualifications of examiner and expert who will testify.
- All tests conducted and the item(s) tested.
- Test results on all items tested.
- Laboratory testing data and bench notes.
- Laboratory reports.
- Laboratory unexpected results and/or corrective action reports.

For more information refer to Module 6, Topic 3, The Significance of DNA Results as Evidence.

Click here to view a sample discovery request.

Continued

Contents of a Discovery Request (cont.)

A discovery request may also seek information about the laboratory's quality assurance program and quality control documentation. Some courts have required disclosure of whether a laboratory technician or scientist had been decertified or suspended, [10] proficiency test results for the particular DNA scientist, [11] information concerning "laboratory protocols, incidences of false positive results, quality control and quality assurance, and proficiency tests," [12] and "the standard operating procedures including the quality assurance manual, in general, the calibration record that went to the laboratory machinery actually used in this case, and the proficiency testing record of the chemist." [13]

Preparing for an Admissibility Hearing

Although most types of DNA test results are now routinely admitted in court, attorneys still request admissibility hearings on some of the more recently developed DNA technologies as well as on novel uses of DNA.

Early consultation with those scientists who may provide expert testimony is recommended.

An in-depth understanding of the scientific issues that will be the subject of the hearing is essential. Consult with the expert to determine which published scientific literature is going to be most helpful.

Expert Testimony in DNA Cases

Every jurisdiction regulates the admission and scope of expert testimony by statute, rule of evidence, or case

law. The two principal standards for expert scientific testimony are the *Frye* 14 and *Daubert* 15 tests.

The Judge's Role

The judge's role in determining admissibility is that of "gatekeeper." The judge applies the *Frye, Daubert,* or other standard at a hearing prior to trial, or outside of the jury's presence, to determine admissibility.

The Frye Test

The *Frye* test is also known as the "general acceptance" test. As the *Frye* court explained:

> Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define...[T]he thing from which the deduction is made must be *sufficiently established to have gained general acceptance in the particular field in which it belongs.*

Continued

The Frye Test (cont.)

Some States use a modified *Frye* test. California, for example, has established a three-pronged test:

- The *reliability of the method* must be established, usually by expert testimony.
- The witness furnishing such testimony must be properly *qualified as an expert to give an opinion* on the subject.
- The proponent of the evidence must demonstrate that correct scientific procedures were used in the particular case. 16

The Daubert Test

The *Daubert* test was announced in an opinion of the U.S. Supreme Court and implemented through the Federal Rules of Evidence. The three main prongs of *Daubert* are as follow:

- The testimony must be based upon sufficient facts or data.
- The testimony must be the product of reliable principles and methods.
- The witness must have applied the principles and methods reliably to the facts of the case. 17

Many states use the *Daubert* standard.

Daubert and "Reliable Principles and Methods"

Daubert, unlike *Frye*, does not require proof that the scientific method itself has general acceptance. Rather, it requires "reliability," which may be proved by considering several factors:

- Whether a method consists of a testable hypothesis.
- Whether the method has been subjected to peer review.
- The known or potential rate of error.
- The existence and maintenance of standards controlling the technique's operation.

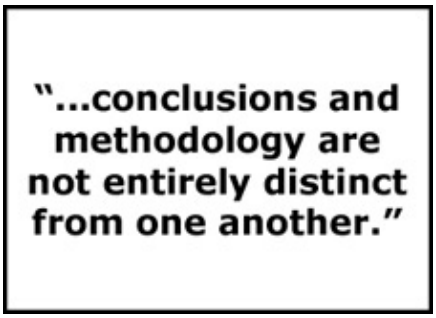
Continued

Daubert and "Reliable Principles and Methods" (cont.)

- Whether the method is generally accepted.
- The relationship of the technique to methods that have been established to be reliable.

- The qualifications of the expert witness testifying based on the methodology.
- The non-judicial uses to which the method has been put.

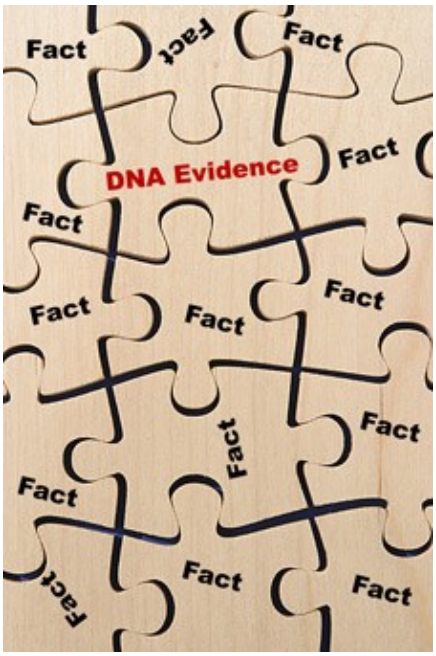
Daubert and Results



Under *Daubert* , the court is not supposed to review an expert's conclusions when deciding admissibility; rather, the court is to assess whether the methodology was properly applied. However, courts may give some scrutiny to the actual conclusions.

The U.S. Supreme Court has explained that "conclusions and methodology are not entirely distinct from one another." A court must examine the expert's conclusions to determine whether they *could* reliably flow from the facts known to the expert and the methodology used. "A court may conclude that there is simply too great a gap between the data and the opinion proffered." 18

"Fit"



There must be a need for scientific evidence in the particular case, and the scientific evidence must fit the facts presented. As one court has explained, evidence must "fit" - that is, it must assist the trier of fact:

> Admissibility thus depends in part upon "the proffered connection between the scientific research or test result to be presented and the particular disputed factual issues in the case." 19

As a general rule, DNA match evidence will fit in cases in which identity needs to be proven or if another physical fact (such as the occurrence of sexual contact) is in dispute.

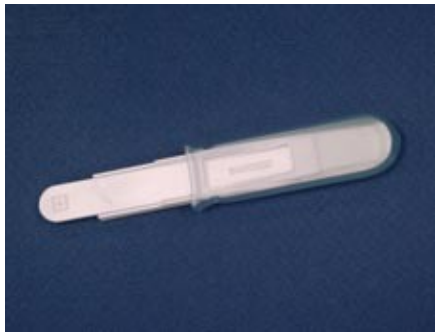
Frye, Daubert, and Acceptance of DNA Testimony

Courts have found DNA testing methodologies (restriction fragment length polymorphism [RFLP] , short tandem repeat [STR], and mitochondrial DNA [mtDNA] testing) and statistical probabilities testimony to meet the *Frye*, *Daubert*, relevancy, reliability and other standards used across the United States. 20

Challenges to Expert Testimony

Although DNA evidence has gained general acceptance and is presumed to be reliable for *Daubert* purposes, its use can be challenged in a particular case. Such challenges occur, for example, when "the procedure used in testing the DNA in this case did not comply with the accepted standards to ensure reliability" 21 and when the testing procedure used, although a variant of a previously approved method, is a new and "materially distinct procedure" that has itself not been proved to meet the *Frye* or *Daubert* standard. 22

Defendant Issues



For a criminal defendant, a DNA-evidence case involves issues of science, proof, the right to expert assistance, and the potential for having to submit to testing. Upon conviction (or as a result of a guilty plea), he or she may be obliged to submit DNA samples to a data bank. Each of these issues warrants a detailed explanation. Informing the accused of his or her rights can facilitate a proper resolution of a case and ensure that the attorney-client relationship is secure.

Search and Seizure Issues

The defendant needs the following information:

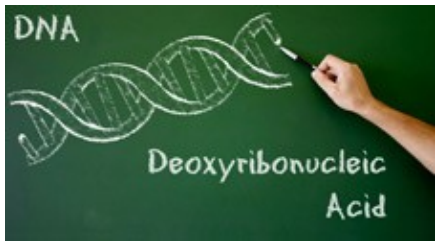
- DNA (or bodily fluids containing DNA) may be seized by court order, or as a result of an arrest.
- Neither the right to privacy nor the privilege against self-incrimination prevents the seizure of DNA.
- Genetic material left at a place where there is no expectation of privacy may be seized.
- Refusing to cooperate in a court-ordered DNA test may be admissible as evidence against the defendant at the time of trial (or at sentencing).

Continued

Search and Seizure Issues (cont.)

- 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.

Science



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.

Defense Requests for Access to DNA Testing Laboratories

The defendant's expert may request to be present during any DNA testing that is conducted by the government's experts. However, some laboratories may have concerns (e.g., security, liability, confidentiality) that would make this access impossible. In such cases, the parties may jointly request that the evidence be sent to an independent DNA testing laboratory. In either circumstance, the parties must agree or a court order must be obtained.

Other laboratories may permit the defense expert to view the testing via remote communication.

The Impact of DNA Evidence on the Defense Theory of the Case

Because of the reliability of DNA testing, a defendant should understand the consequence of asserting a defense that might contradict the results of DNA analysis. Likewise, it is important for the defendant to understand that results of DNA analysis could support a claim of innocence.

On the other hand, if the defendant could not have been the source of the DNA evidence, a defense demand for DNA testing is critical to ensure a prompt determination of the case and secure potentially exculpatory, or even exonerating, evidence.

Post-trial Consequences of DNA Testing

The defendant needs to know the following information:

- Except in cases in which DNA is obtained by limited consent (See Module 10), 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.

Defense: Appointment of Experts

An indigent accused of a crime has a constitutional right to expert assistance financed by the court or prosecuting county. 23 In the *Ake* decision, the Supreme Court affirmed the need of the State to ensure an indigent "access to the raw materials integral to the building of an effective defense."

The Right to a State-Funded Expert

The right to a State-funded expert for the defense is not absolute. Rather, it involves assessment of "the probable value of the [expert] assistance sought, and the risk of error in the proceeding if such assistance is not offered." 24

Functions of the Defense Expert

An expert for the defense can serve multiple functions:

- Analyze and interpret the prosecution's laboratory report and data.
- Identify possible errors or omissions committed by the prosecution's testing laboratory or in evidence handling prior to the laboratory testing.
- Observe analysis when appropriate (e.g. limited sample cases).
- Evaluate the need for or conduct independent tests on the biological material.
- Offer testimony at trial to address the accuracy or significance of the DNA evidence.

Continued

Functions of the Defense Expert (cont.)

- Prepare defense counsel for challenging or presenting the DNA evidence.
- Offer testimony at trial to address the accuracy or significance of the statistical probability testimony.
- Present exculpatory DNA evidence testimony.
- Address shortcomings of any newer DNA procedure, either at a pretrial hearing to determine admissibility or at trial.
- Help defense counsel inform the client of the weight and significance of the government evidence prior to trial and thereby permit an informed decision on whether to have a trial or enter a plea. [25]

Motion to Secure a Defense Expert

To secure an independent defense expert, counsel must file a motion pleading the defendant's indigence, the type of expert service(s) needed, the case-specific need for this assistance, the estimated cost of such service(s) based on actual proposals from qualified experts, and the reasonableness of those costs. Counsel may supplement the motion with affidavits from other attorneys confirming the need for this type of expert assistance.

Expert Assistance: Disclosure of Theory of Defense

If the request for expert assistance involves disclosure of a theory of defense, counsel for the defendant may seek to submit the motion *ex parte* and under seal, request that any court proceeding addressing the request be held *in camera*, and have the record from that hearing also be placed under seal. This process ensures the creation of a full record and permits appellate review if the request is denied.

When to Request Expert Assistance

The typical request for expert assistance is made at the trial level in State court. The response of State appellate courts has been mixed when a trial judge has denied the request. Courts supporting the right to expert assistance have explained it as follows:

> Given the weight that a jury could place on DNA tests and the statistics drawn from them, coupled with the unlikelihood that defense counsel will have the expertise to challenge that evidence, we hold that an indigent defendant against whom DNA evidence will be offered must have access to a DNA expert to assist in his defense. 26

Denial of Funds for DNA Experts

In cases in which courts have affirmed the denial of funds for DNA experts, the rationale expressed is that the defendant or defense counsel failed to fully and clearly plead the need for expert services, the cost, and the manner in which the expert would assist the defense. 27

Failure to Seek a DNA Expert

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. 28 This determination must be made on a

case-by-case basis.

Special Considerations for the Prosecution: Prioritization of DNA Testing of Biological Materials

Crime scene technicians may collect numerous items of evidence that could contain biological material. Similarly, they will often collect individual items such as carpets or motel bedspreads that are likely to contain biological material from numerous sources.

Prosecutors should consult with the DNA analyst assigned to the case to determine which samples are most likely to yield probative DNA results.

Splitting Evidentiary Samples: Post-Charge

In some States, after a defendant has been charged, the prosecution is required to preserve evidentiary biological material for the purpose of DNA testing by the defense.

At times, the evidentiary biological material may be too minute to divide; it is good practice to consult with the laboratory on the feasibility of dividing the sample.

In States that require such, the government should inform defense counsel and seek the court's permission to consume the sample if there is no other option.

Providing Discovery of DNA-related Test Results

It is good practice for the prosecutor to meet with the DNA analyst(s) involved in the case well before trial date to ensure that all discoverable reports, notes, chain of custody documentation, written correspondence, and analysis results have been provided.

Pretrial Conferences with Government Experts

As early as possible, prosecutors should meet with the laboratory scientists who have performed the DNA work in an individual case to review all of the reports generated, discuss any anomalies that may be present, ensure proper chain of custody, and review the work of the defense laboratory, if applicable.

Continued

Pretrial Conferences with Government Experts (cont.)

Particularly in older cases, the laboratory scientist should be consulted as to whether additional DNA typing with newer technologies may yield more informative results.

It is important to inquire of analysts as to whether they or their laboratories have had problems with proficiency tests or laboratory procedures.

The Prosecution's Access to Defense DNA Testing Results

The laws pertaining to discovery obligations of defense attorneys regarding DNA testing results will vary by jurisdiction. Generally, the defense is required to produce, "as part of the discovery process," DNA test results that they will introduce at trial.

Where applicable, prosecutors should request discovery regarding the defense lab's relevant standard operating procedures, as well as validation studies, proficiency test results, contamination issues, and so forth.

Continued

The Prosecution's Access to Defense DNA Testing Results (cont.)

Prosecutors should review the results of the defense lab's test results with their own experts to identify discrepancies or problem areas. Based on the test results, the prosecutor may request additional DNA testing.

Informing DNA Testing Laboratory When Testing is No Longer Needed

Most forensic laboratories have overwhelming caseloads. As soon as the prosecutor resolves a case and determines that DNA testing is no longer needed, the forensic laboratory should be informed. This will enable the forensic analysts to move on to the next case, saving personnel, time, and financial resources.

Module Objectives Review

If you have successfully completed Module 11, you should be able to:

- Understand discovery issues involved with DNA evidence.
- Recognize pretrial legal questions related to DNA evidence.
- Have knowledge of specific discovery items requested in cases in which DNA testing occurs.
- Recognize issues important to defendants in criminal cases with potential DNA evidence.
- Recognize DNA-related issues for persons who plead guilty to, or are convicted of, criminal charges.

You have successfully completed Module 11, Pretrial DNA Evidence Issues. Proceed to Module 12, Victim Issues.

Module Objectives

Upon completion of Module 12, you will be able to:

- Recognize issues important to victims in cases involving the use of DNA evidence.
- Recognize legal and scientific issues related to the role of the victim in the criminal case.

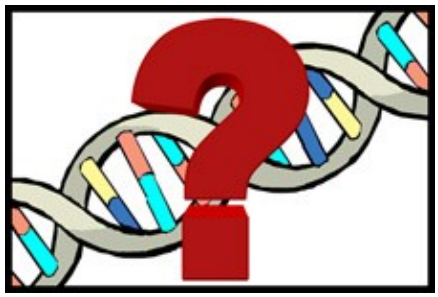
Victim Issues

Crime victims often will have many questions about the use of DNA evidence in their case. Especially for victims of violent crimes, the case likely involves one of the most significant events of their lives and they will have an expectation that it will be *their* case.

The questions will typically fall into the following categories:

- DNA evidence
- DNA evidence testing
- Privacy and procedural considerations

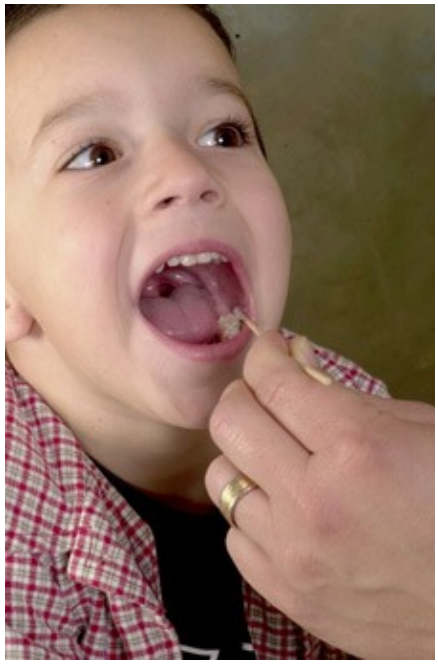
DNA Evidence



Victims may have basic questions about DNA:

- Where can DNA evidence be collected? For more information see Module 3, Topic 1, Crime Scene Issues Related to DNA Evidence.
- If property is taken, will it be returned and in what condition?
- What is a reference sample and how is it used? For more information see Module 3, Topic 2, Initial Considerations in Laboratory Protocol.
- After the reference samples are collected, where are they taken and what is done with them? Why are samples taken from the victim, or others, necessary?
- For how long will samples be kept, by whom, and for what purpose?

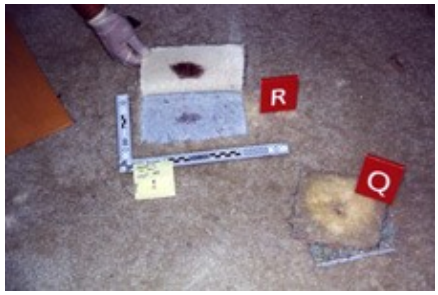
Where Can DNA Evidence Be Collected?



Victims should be informed that their DNA may be recovered from:

- The crime scene. For more information see Module 3, Practical Issues Specific to DNA Evidence.
- Their person (e.g., external body swab, sexual assault examination, reference samples).
- The suspect's person.

DNA Evidence and the Investigative Process



There are factors the victim should be aware of during the investigative process.

Clothing, carpet, linens, or other personal possessions that may contain relevant DNA evidence may be removed, cut, or destroyed. This may place additional stress on the victim and should be conveyed at the onset of the investigation.

If Property Is Taken, Will It Be Returned and in What Condition?

Personal property may be needed because biological material from the perpetrator might be present on those items. Because DNA profiles may be obtained from items of evidence that are decades old, law enforcement may retain unanalyzed evidence indefinitely. Items of evidence that have been analyzed for DNA will generally only be returned once the court process is final.

State laws may require that the victim's property be returned.

Continued

If Property Is Taken, Will It Be Returned and in What Condition? (cont.)

A portion of an evidentiary item may be removed by the forensic laboratory in order to analyze biological material that might be present.

What Is a Reference Sample and How Is It Used?

Biological known reference samples such as blood or saliva can be collected from the victim, suspect, a consensual sex partner(s), relatives or any other person who might have had access to the crime scene during the course of a criminal investigation or trial. These samples can be used to identify and/or exclude the source of the DNA profile(s) contained in the evidence sample.

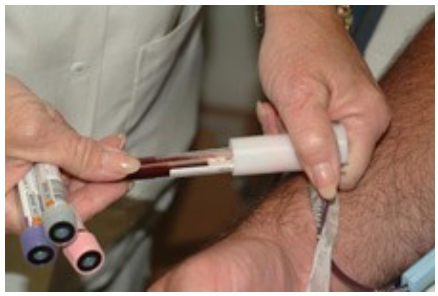
It is imperative that reference samples are collected as soon as possible to allow for the forensic analysis to progress.

After Reference Samples Are Collected, Where Are They Taken, and What Is Done With Them?

Once samples are collected, they are stored in a secure facility for future testing by the DNA laboratory. Victims should be advised that there may be delays in testing, due to factors such as laboratory backlogs or analysis complexity.

Additionally, the victims should be aware that they, or others, may be requested at a later date to submit reference samples for testing.

For How Long Will Samples Be Kept, by Whom, and for What Purpose?



Jurisdictional policies may vary regarding the retention and use of victim, suspect and other known reference samples. Some jurisdictions require that samples be destroyed, while others require a formal request and/or court order for the destruction or return of biological material. Biological material collected in a criminal investigation is strictly limited to use for law enforcement purposes.

DNA Evidence Testing

Victims will have basic questions about DNA evidence:

- How is evidence tested?
- Who is responsible for doing the test?
- How long will it take and when will the results be available?
- What is the significance of the results?
- Who will have access to the results?
- What are the defendant's rights?

If there is no DNA evidence in their case, victims will want to know why.

How Is DNA Evidence Tested?

Once evidence is submitted to the forensic laboratory, tests that have been accepted by the scientific community are used to analyze the DNA contained in biological evidence. This is done to compare DNA

profiles from known reference samples with DNA profile(s) from evidentiary material. For more information, see Module 4, Introduction to the Forensic DNA Laboratory.

The online version of this course contains a multimedia [or downloadable] file. Visit this URL to view the file: http://forensic.dna.gov/module12/2/002

Who's Responsible for Doing the Test?

Typically, a government forensic laboratory will be responsible for conducting the DNA analysis. However, sometimes DNA casework will be sent to a private laboratory for testing. The defendant's attorney may request that additional testing be conducted by the same or a different laboratory.

How Long Will It Take and When Will the Results Be Available?

Many forensic laboratories throughout the country have a backlog of DNA casework that can range from months to more than a year. Once testing begins, the length of time necessary to complete the analysis is based on the complexity of the case (i.e., from weeks to months). Testing status updates should be requested.

It is important to communicate with the forensic laboratory to determine which items of evidence need to be analyzed and, consequently, how long it might take to obtain DNA analysis results. For more information on DNA evidence testing, see Module 3, Practical Issues Specific to DNA Evidence.

What Is the Significance of the Results?

It is important to realize that the presence of more than one DNA profile on an evidentiary item must be considered in the context of other evidence and circumstances of the case. For example, if a suspect's DNA profile is obtained from the analysis of a swab from a rape kit, it demonstrates that a sexual act occurred but does not answer the question of consent or the timing of events. The crime laboratory will usually generate a report with an interpretation of the results of DNA analysis, which can sometimes assist in determining the significance of results. For more information on laboratory reporting, see Module 6, Understanding a Forensic DNA Lab Report.

Who Will Have Access to the Results?

The forensic laboratory, law enforcement, prosecutor, defendant, and defendant's legal representative will all have access to results of DNA analysis. A victim's access to test results may be obtained through the prosecutor's office; however, this may vary by jurisdiction.

Once evidence is introduced in court, it becomes part of the public record, unless otherwise ordered by a judge. Public records laws vary. In some jurisdictions, laboratory reports may be publicly accessible.

What Are the Defendant's Rights?

Depending upon the jurisdiction, the defendant may have access to all prosecution DNA analysis results.

Why Is There No DNA Evidence or Results from DNA Analysis?

DNA is transferred to an item of evidence through the physical transfer of biological material such as blood or saliva. While biological material that is properly collected, packaged, and stored can successfully be tested for DNA many years after the commission of a crime, sometimes environmental or other factors can degrade DNA, which can negatively affect DNA analysis results.

For more information on factors affecting DNA analysis, see Module 3, Practical Issues Specific to DNA Evidence.

Privacy Issues

Victims increasingly have privacy concerns about the use of DNA evidence in cases involving samples taken from the victim or others.

- What information about the victim or others will the test results reveal?
- Who outside of law enforcement will have access to samples or test results?
- The Health Insurance Portability and Accountability Act (HIPAA) may limit the availability of medical records pertaining to victims. Victims should be informed if their DNA/scene evidence has been tested. Access the HIPAA website at http://www.hhs.gov/ocr/hipaa/

Privacy-Related Questions

What information about the victim or others will the test results reveal?

Forensic DNA test results currently do not contain information on physical characteristics (e.g., hair color, eye color) or medical conditions of the person who contributed the DNA. However, they usually do reveal the gender of the sample donor(s).

Continued

Privacy-Related Questions (cont.)

Who outside of law enforcement will have access to samples or test results?

The defendant may be entitled to test results related to the case.

Parties outside of the criminal process, such as insurance companies, employers, the news media, and general public may request information regarding a case.

Continued

Privacy-Related Questions (cont.)

Does the Health Insurance Portability and Accountability Act (HIPAA) limit the availability of medical records pertaining to victims?

HIPAA strictly limits the release of victim medical information except with the victim's written consent and for the specific people it will be released to. However, if a case is under police investigation, evidence can be released without the victim's consent to law enforcement and other involved parties for the investigation. Nevertheless, signed consent is still obtained.

Procedure/Participation Issues - The Role of the Victim

The role of crime victims in criminal cases has evolved throughout the history of the country, and it is changing again in many jurisdictions. At the time the country was founded, victims were most often full parties in criminal cases because the common law favored private prosecution for public offenses. This system persisted well into the 19th century; by the 20th century, however, it had been replaced by a system of public prosecution. In this system, victims were witnesses but had no independent role. The last 20 years have seen reform of the victim's role, and these changes have implications for cases involving DNA evidence.

The Rights of Victims

In 33 states, crime victims have constitutional rights that may give them an independent voice in criminal cases.

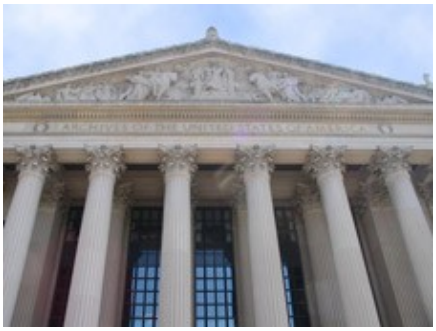
See Alabama Const. amend. 557; Alaska Const. art. I, Sec. 24; Ariz. Const. art. II, 2.1; Cal. Const. art. I, 12, 28; Colo. Const. art. II, 16a; Conn. Const. art. I, 8(b); Fla. Const. art. I, 16(b); Idaho Const. Art. I, 22; Ill. Const. art. I, 8.1; Ind. Const. art. I, 13(b); Kan. Const. art. 15, 15; La. Const. art. 1, 25; Md. Decl. of Rights art. 47; Mich. Const. art. I, 24; Miss. Const. art. 3, 26A; Mo. Const. art. I, 32; Mont. Const. Art II, sec. 28;

Neb. Const. art. I, 28; Nev. Const. art. I, 8; N.J. Const. art. I, 22; New Mex. Const. art. 2, 24; N.C. Const. art. I, 37; Ohio Const. art. I, 10a; Okla. Const. art. II, 34; Art. 1, Sec. 42, Or. Const.; R.I. Const. art. I, 23; S.C. Const. art. I, S 24; Tenn. Const. art. 1, 35; Tex. Const. art. 1, 30; Utah Const. art. I, 28; Va. Const. art. I, 8-A; Wash. Const. art. 2, 33; Wis. Const. art. I, 9m.

All States have statutes or court rules that may provide victims substantive and participatory rights.

Continued

The Rights of Victims (cont.)



Victims' rights of special significance in DNA cases may include:

- A right to privacy.
- A right to be treated with dignity and respect.
- A right to refuse a direct discovery request from the defense.
- A right to a speedy trial.
- A right to a return of property.

Continued

The Rights of Victims (cont.)

- A right to consult with the prosecutor and to read reports relating to the case and defendant.
- A right to notice of and to be present at all proceedings including postconviction and/or parole.
- A right to be heard at critical proceedings through the postconviction process, including proceedings that involve hearings on DNA evidence if they could lead to a release of the defendant, requests for extensions of time, and plea agreements.
- A right to be informed of the planned destruction of biological evidence.

Module Objectives Review

If you have successfully completed Module 12, you should be able to:

- Recognize issues important to victims in cases involving the use of DNA evidence.
- Recognize legal issues related to the role of the victim in the criminal case.

You have successfully completed Module 12, Victim Issues. Proceed to Module 13, Trial Presentation.

Module Objectives

Upon completion of Module 13, you will be able to:

- Present DNA evidence to a jury or a judge in a simplified but understandable manner.
- Prepare direct-examination and cross-examination of experts.
- Properly characterize DNA evidence throughout the trial.

Jurors and DNA Evidence

To most jurors, DNA evidence may seem complex and confusing. Although many jurors may have heard of DNA testing and know that it can be a valuable investigatory tool, most will not be familiar with the actual technology or how scientists use it to compare evidence with known samples and arrive at identification conclusions. Qualified experts may be helpful in explaining the evidence to the jury.

Pretrial preparation with an expert is essential to ensure a familiarity with the evidence and the subject area about which the expert will testify.

Media Effect

Because of both the popularity of fictional television programs focusing on forensic science and media coverage of high-profile cases, jurors may have unrealistic expectations of forensic laboratories' capabilities.

Continued

Media Effect (cont.)

Jurors may hold incorrect beliefs about DNA testing (e.g., that it *always* uniquely identifies an individual). Jurors may also expect DNA evidence to be presented in *every* case (even those in which no biological evidence was detected, those in which DNA results would not be probative, or those in which resource restrictions and other available evidence may make DNA testing cost prohibitive or otherwise unnecessary). As a result of these expectations, prosecutors may have to explain why DNA testing was not performed or why no results were obtained.

DNA and Negative Publicity

Preexisting beliefs about the possibility of laboratory errors and intentional tampering may affect how a jury weighs DNA results. Jurors who have received such information in the press or from other sources may give DNA evidence less weight than is scientifically appropriate. 1

Expert Qualifications

The first step to ensure that jurors understand and accept DNA evidence is to qualify the expert in the applicable field. The party presenting the evidence should demonstrate that the expert has appropriate scientific credentials and is objective.

If the opposing party offers to stipulate to the qualifications of the expert, the presenting party should still have the expert briefly summarize his or her background for the jury as permitted by the court.

Click here to view a video of an expert providing her background.

Organizing the Presentation of DNA Testimony

There are many resources available that can provide guidance in the formulation of questions for the expert.

Sample Opening Questions

Q: Did your lab conduct testing on evidence from the crime scene in this case?

Q: Tell the jury what types of crime scene evidence you tested and whether you compared that against the DNA of any suspect?

Q: And were you, in fact, able to identify the person who left that evidence at this crime scene?

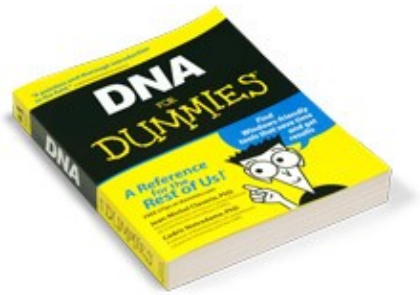
Q: Before we get to the identification, let us first turn to exactly what DNA is. Do you have some charts to show the jury what a DNA molecule looks like and how it is used to identify people?

Sample Concluding Questions

Q: You have told us about the scientific techniques used and the evidence tested. Can you tell this jury whose DNA was found in the [evidence sample] at this crime scene?

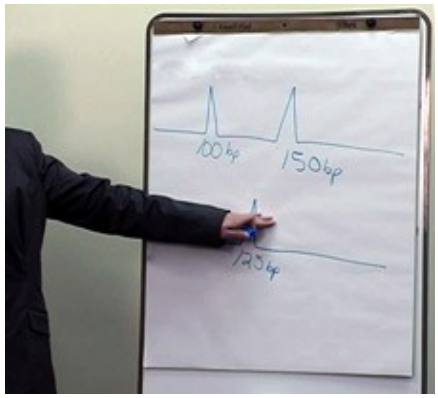
Q: And can you tell the jury, statistically, the odds that it was this person as opposed to any other person in the world?

Framing Questions To Educate the Jury



It is not necessary that the jury be provided with an in-depth explanation of DNA testing, but enough information should be relayed so jurors are able to intelligently and fairly evaluate the evidence. Thorough pretrial preparation with the witness will facilitate this process.

Making Forensic DNA Testimony Understandable



DNA testimony may introduce scientific and statistical terms that should be defined and explained to the jury as simply as possible.

Testimony may include the basics of inheritance, testing methods, how forensic scientists are able to use DNA technology to include or exclude individuals as the source of the evidence, and statistical interpretations.

The use of analogies to explain some concepts may make the testimony more understandable. Visual aids may be used to illustrate key points, in appropriate cases.

Pretrial Preparation

Counsel should consult with the expert prior to trial to ensure that he or she sufficiently understands the DNA evidence and its significance in the case. In addition, counsel should work with the expert to ensure that the courtroom presentation uses language and exhibits that make the science and findings comprehensible to the judge and jurors.

Expert Witness Preparation

It is essential that attorneys and experts discuss the case facts and testimony prior to trial so that the extent of technical detail is predetermined and the attorney made aware of any potential weaknesses in the result and/or the technology used.

If the attorney is unfamiliar with DNA, a primer on DNA testing should be reviewed prior to trial.

If the witness is new to testifying, a primer on rules of evidence, direct and cross examination, and courtroom etiquette should be reviewed.

Continued

Expert Witness Preparation (cont.)

Pretrial preparation for expert testimony should review:

- What was analyzed (including chain of custody questions).
- Testing procedures used.
- Reasons for inconclusive/no result.
- Significance of results.
- Accreditation and certification of the laboratory and personnel.
- Laboratory's quality assurance program (include proficiency testing).
- Qualifications and history.
- Exhibits/Demonstrative evidence.
- Manner in which testing results will be presented.
- Areas likely for cross-examination.

Expert Testimony and Evidentiary Rules

Both the expert and the attorney must be familiar with the governing rules of evidence. Those rules may require:

- A pretrial determination of the admissibility of expert testimony.
- Having the expert state his or her opinion.
- Having the expert identify the underlying facts and data relied upon in reaching that opinion.
- Non-disclosure of facts and data relied upon by the expert but not admissible under applicable rules of evidence.

Online Link - Click here to view the Federal Rules of Evidence.

Court-Appointed Experts

Sometimes additional experts are appointed by the court. They may testify in addition to the government or defense expert at a pretrial hearing or at the trial itself.

Online Link - Click here to view information on expert testimony contained in the NRC II report.

Openings in a DNA Case

During the opening statement, attorneys should be careful not to misstate or overstate the character of the DNA evidence that will be presented.

Direct: Expert Voir Dire

Introduce the witness and discuss his or her qualifications:

- Education.
- Current job duties.
- Work experience/training.
- Professional associations.
- Licenses/board certifications/proficiency tests.
- Presentations/lectures/teaching.
- Publications, peer-reviewed and others.
- Prior testimony/prior qualification by courts as expert.
- Testimony for defense as well as prosecution.

Direct Examination

- Was crime scene evidence tested?
- Was DNA from a suspect tested?
- Was there a match?
- Explanation of DNA.
- Explanation of testing conducted in this case.
- Item(s) tested (and chain of custody).
- Opinion.
- Information used to arrive at opinion.

- Basis of opinion.
- Methodology, including non-forensic uses.
- Consideration of alternatives and contrary theories.
- Identification of defendant as the source of the evidence
- Charts.

Cross-Examination

Although most forensic DNA testing methods have been accepted by courts in all 50 States, challenges are still made, for example, in areas such as the education, training, and experience of a particular analyst. It also might be explored whether the analyst might be biased in some way; whether all relevant testing precautions were taken on quality assurance procedures followed; and the level of certainty of the results. 2

Cross-examination may also elicit the limits of DNA evidence in that case. For example, DNA analysis cannot determine when or how the biological material was deposited at a particular location.

Reviewing transcripts of prior testimony of specific experts may be helpful.

Click here to view a video of a cross-examination.

Closing Argument and DNA Evidence

To avoid legal error, care should be taken in the preparation of and during the closing argument, just as in the opening statement, not to misstate or overstate the character of the DNA evidence that has been presented.

Module Objectives Review

After completing Module 13, you should be able to:

- Present DNA evidence to a jury or a judge in a simplified but understandable manner.
- Prepare direct-examination and cross-examination of experts.
- Properly characterize DNA evidence throughout the trial.

You have successfully completed Module 13, Trial Presentation. Proceed to Module 14, Postconviction DNA Cases.

Module Objectives

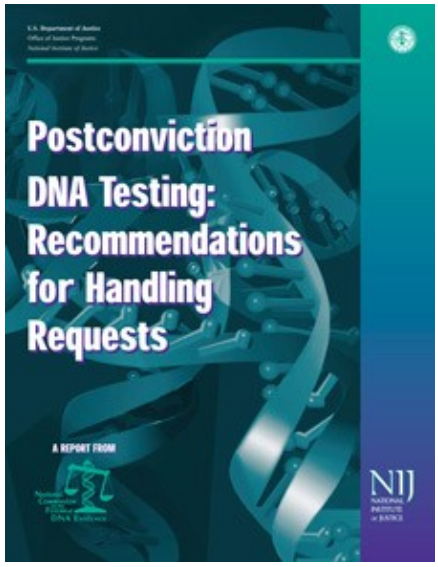
Upon completion of Module 14, you will be able to—

- Understand the framework within which State postconviction DNA case testing may be pursued.
- Identify issues specific to the existence, location, and condition of biological evidence.
- Understand legal and procedural issues that should be considered in State postconviction DNA cases.

A Framework for Considering Postconviction DNA Cases

The extraordinary power of DNA typing techniques has led persons convicted of crimes - often decades earlier - to seek testing to corroborate claims of innocence. The nature of the case and biological evidence that remains available for analysis can dramatically affect the resolution of such assertions.

Factors in Postconviction DNA Testing Requests



Factors to consider in determining whether to conduct postconviction DNA testing (by agreement or court decision) include:

- The legal standard governing postconviction DNA testing in the applicable jurisdiction.
- The petitioner's current status.
- The potential probative value of testing existing biological evidence.
- Other evidence in the case.
- Whether a conviction is based on a guilty or no contest plea, or following a trial.
- The availability and type of DNA testing at the time of trial.

Online Link - Click here to view the National Institute of Justice publication, *Postconviction DNA Testing: Recommendations for Handling Requests.*

Classifications

Potential postconviction cases can be classified into five broad categories to assist in the consideration of whether DNA testing should be pursued.

Depending on the legal standard governing State postconviction DNA testing in the applicable jurisdiction, DNA testing may be of value in appropriate cases that are classified into categories 1-3. 1 DNA testing will likely not be performed in cases that fall into categories 4 or 5.

Category 1

In these cases in which biological evidence was collected and still exists, DNA results excluding the petitioner may exonerate him or her as the perpetrator of the crime.*

Example: Petitioner was convicted of the rape of a sexually inactive child. While vaginal swabs were taken and preserved, no previous DNA testing was conducted. DNA testing that excludes the petitioner as the source of the sperm will establish actual innocence. Note that in such a case, the victim's DNA - normally also present on the vaginal swab - operates as a control that confirms that the correct sample is being tested. In addition, the victim's age and sexual status at the time of the offense ensure that the swab contains only biological material related to the crime.

*Be aware of complex issues that arise in mixture cases.

Category 2

In these cases in which biological evidence was collected and still exists, DNA results could support a claim of innocence, but reasonable disagreement could exist whether the results exonerate the petitioner.

Example: Petitioner was convicted of a homicide. The prosecution presented evidence and argued in closing that blood on a shirt found at petitioner's home came from the victim. Standard ABO blood typing had revealed a match between the sample and the victim's blood type. DNA testing that excludes the victim as a source of the bloodstains might be helpful to the petitioner's claim, yet not establish innocence.

Category 3

These are cases in which biological evidence still exists. Results of DNA testing may provide additional, albeit inconclusive, information as to guilt or innocence.

Example: Petitioner is presently incarcerated for a multiple-assailant rape. The victim testified that seven perpetrators were involved but is uncertain whether all actually engaged in sexual intercourse. If vaginal swabs that were preserved are tested and petitioner's DNA profile is not found, the significance of the results will be minimal because they may not significantly undermine confidence in the outcome of the proceedings. It should be noted that if other participants in the rape can be identified through DNA testing and the petitioner can show the unlikelihood that he ever had contact/association with the other participants, this case may fall

into category 1 or 2.

Category 4

These are cases in which biological evidence was never collected, cannot be located, was destroyed, or was stored under conditions preventing successful DNA typing. In these cases, postconviction relief on the basis of DNA is not possible.

Category 5

These are cases in which a request for DNA testing is frivolous.

Considerations for these cases include, among other things, whether:

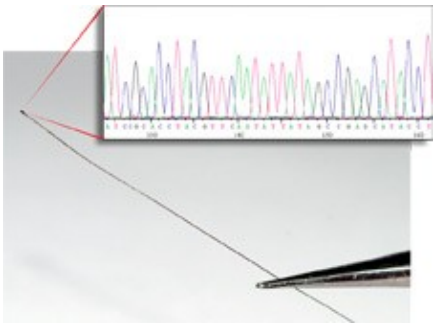
- A voluntary and reliable confession was obtained.
- A guilty plea was entered.
- The petitioner testified to performing the charged act, but raised a defense such as consent, self-defense, duress or entrapment.
- The petitioner was apprehended in the act or other strong evidence of identity or involvement exists, such as fingerprint evidence.

Example: The trial transcript discloses the existence of other evidence that makes the petitioner's claim meaningless, as in a burglary conviction in which the petitioner was apprehended at the crime scene.

Category 1-3 Cases

Because DNA testing will likely not be pursued in cases that fall into categories 4 or 5, issues addressed in the remainder of this module will apply to cases that can be classified into categories 1-3.

Biological and Laboratory Issues



Recent advances in forensic DNA technology have enabled scientists to successfully analyze smaller, limited, degraded, and mixed biological samples. Therefore, any otherwise suitable biological sample that still exists, regardless of age, may be considered for DNA analysis.

For example, shed hairs previously examined only microscopically can now undergo mitochondrial DNA analysis.

Previous Test Results

Issues to be considered when DNA testing was previously performed include:

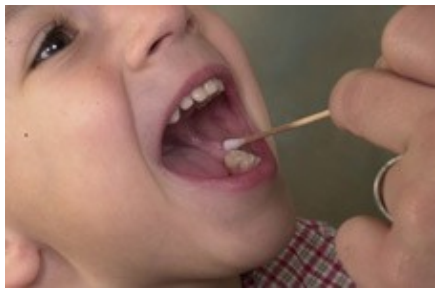
- What items of evidence existed at the time of the trial?
- What type of analysis or tests were performed on the evidence?
- What are the limitations of the tests that were performed?
- Were the results presented at trial and, if not, why?

Sample Selection

Caution should be exercised to select samples for testing that provide the greatest likelihood of meaningful results for a particular case. It may be necessary to consider previously collected evidence samples to determine if:

- Other relevant evidence samples exist that could be tested.
- Samples exist containing biological material that was previously undetected or not evaluated by the laboratory.
- Samples have been retained that were unsuitable for testing with previous techniques but may provide probative results with current technology.

Reference Samples



Obtaining additional known or reference samples from the petitioner, the victim, any consensual sex partners, family members, or other individuals may be necessary if not originally collected or if such samples are not suitable or cannot be located.

The issue of obtaining reference samples should be carefully considered. A court order to collect the samples may be necessary if the victim or third party will not agree to provide samples.

Legal / Procedural Issues

Requests for postconviction DNA testing present unique issues for trial courts and are complicated in many jurisdictions by laws governing newly discovered evidence and time bars. Post-conviction cases litigated in court will normally fall into Category 1 or Category 2.

These categories were discussed earlier in this module.

Petitioner Requests

A petitioner seeking postconviction DNA testing will normally request:

- Discovery of, and access to, physical evidence to permit evaluation and DNA analysis (and, if indigent, at state expense).
- The opportunity to present favorable test results in a judicial proceeding (or executive proceeding for clemency, commutation, or pardon).

Access

The law in many jurisdictions is not clear as to the legal theory and procedures that entitle a petitioner to seek access to evidence, testing, and potential relief.

Impact of Postconviction Litigation

Consequently, litigation of postconviction DNA cases is often complex, cumbersome, expensive, and time consuming. Officers of the court should cooperate in locating evidence, arranging for testing, and requesting judicial or executive relief when appropriate to further the interests of justice.

Numerous legal and practical issues arise when a motion or application for postconviction DNA testing and relief is filed. Attorneys and the judiciary must become familiar with the applicable law in their respective jurisdictions.

Victim/Survivor Considerations

In some jurisdictions, the law requires notice to the victim of his or her right to be present and heard at postconviction proceedings. It is important to consult with the local victim/witness specialist to determine whether and when to advise the victim or survivors of the request for DNA testing. It is always preferable to have victims or survivors learn of the request from a trained professional rather than the news media. In appropriate circumstances, the court might consider whether a "no contact with the press" order should be issued to protect the interests of the victim and/or survivors.

Relevancy Determination

Ultimately, an initial relevancy determination whether the case is suitable for DNA testing and whether test results may support the petitioner's claim for relief is one of the most important stages of the process.

Determining the relevance of further DNA testing should include a collaborative evaluation of the case by postconviction counsel and a forensic DNA expert.

Locating Evidence

If DNA testing is determined to be appropriate by agreement or by court order, an attempt should be made to locate all physical evidence. Items not traditionally thought to contain usable DNA evidence, such as slides taken by medical personnel, might be valuable in the context of a postconviction case.

Locating Evidence (cont.)

Locating evidence is often a barrier to conducting DNA testing. Evidence may be routinely destroyed with no malicious intent. Suggested locations to search include:

- Law enforcement evidence or property rooms.
- State and local crime laboratories.
- Hospitals, clinics or doctors' offices.
- Medical examiner's or coroner's office.
- Independent crime laboratories.
- Clerks of court (including vaults).
- Court reporter's files and storage areas.
- Prosecutor's office.

Continued

Locating Evidence (cont.)

Responsibility for the preservation and maintenance of physical evidence varies according to jurisdiction. The court can play a significant role in the search for evidence via court order or subpoena directing custodial agencies to search for physical evidence.

If evidence has been destroyed or cannot be located, this should be confirmed in writing by the appropriate authority. In many cases, while the original item of evidence may have been destroyed, extracts, glass slides, or cuttings may still be available for testing.

Laboratory Testing

If evidence suitable for testing has been located, the parties and/or court must determine the laboratory and testing methods to be employed.

Results From DNA Tests

All results of laboratory analysis should be considered in the context of the case, and carefully coordinated with the court to ensure victims and survivors are appropriately notified. For more information on DNA test results, see Module 6, Topic 3, The Significance of DNA Results as Evidence.

Test Results and the Court

If test results are favorable to the petitioner and the jurisdiction's standard for relief is met, counsel and the court should consider whether a new trial should be ordered or the charges dismissed.

Continued

Test Results and the Court (cont.)

When a time bar precludes judicial action, the court or counsel may forward the testing results to the appropriate agency for consideration in a request for executive clemency, commutation or pardon.

Module Objectives Review

If you have successfully completed Module 14, you should be able to:

- Understand the framework within which State postconviction DNA case testing may be pursued.
- Identify issues specific to the existence, location, and condition of biological evidence.
- Understand legal and procedural issues that should be considered in State postconviction DNA cases.

You have successfully completed Module 14, Postconviction DNA Cases. Proceed to Module 15, Emerging Trends.

Module Objectives

Upon completion of Module 15, you will be able to—

- Recognize some new forensic DNA technologies that are being developed.

Single Nucleotide Polymorphisms (SNPs)

The forensic science community continues to seek methods that can expand the range of sample types that may be tested. Just as short tandem repeats (STRs) were developed so that smaller and more degraded samples could be tested than with restriction fragment length polymorphism (RFLP) , single nucleotide polymorphisms (SNPs, often pronounced "snips") can be used to obtain results from even smaller and more degraded DNA samples than with STRs.

Conventional DNA testing methods may not yield results when DNA is highly degraded. For example, in the World Trade Center terrorist attack, DNA of the victims was subjected to such extended periods of extreme temperature that conventional testing could not be used to identify human remains.

Continued

Single Nucleotide Polymorphisms (SNPs) (cont.)

SNPs are the most common type of genetic markers found in humans. On average, every thousand bases in human DNA will contain a nucleotide site that can differ between individuals (biallelic).

Continued

Single Nucleotide Polymorphisms (SNPs) (cont.)

An example of a SNP would be the sequence ATTGC***C***CGTGTGAT, which in some individuals would comprise an alternative form (or allele) ATTGC***A***CGTGTGAT because a C has been replaced by an A at a particular location. There are more than one million of these biallelic SNPs in the human genome.

Application of SNPs Analysis

While the future utility of SNPs is uncertain, it seems unlikely that this method will replace the standard set of STRs used for routine DNA analysis due to the limited variation of SNPs and difficulties with mixed sample interpretation.

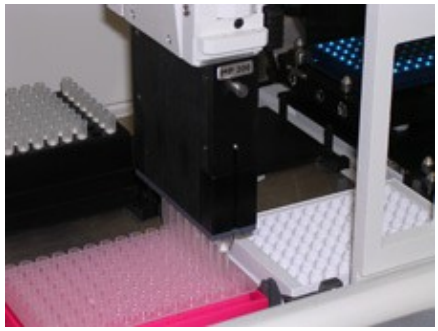
Automation

Many laboratories have automated the DNA analysis process for the following reasons:

- Reduced cost.
- Time and efficiency.
- Reduced likelihood of human error.

Continued

Automation (cont.)



Steps in the process that can be automated include:

- DNA extraction.
- DNA quantitation.
- Polymerase chain reaction (PCR).
- Capillary electrophoresis (CE).
- Data analysis.

Continued

Automation (cont.)

A number of robotic platforms that perform programmable tasks, such as liquid handling and physical manipulations, are capable of automating one or more of the processes of DNA extraction, quantitation and PCR. However, human intervention is required to move samples from one robotic platform to the next. Expert systems are being developed to automate data analysis. Future developments are expected to integrate the automation of all steps in the process with minimal human intervention.

Microarrays (Chip Technology)

The desire to increase laboratory throughput of DNA typing has led to the development of microarrays. Small, single-use plastic chips are manufactured that hold selected DNA fragments to which SNPs from an evidentiary or known sample will bind or hybridize. Hybrization that has taken place on the chips after the addition of extracted and amplified DNA is signaled by light emitting chemicals and detected inside an instrument. High throughput automation of this system is possible.

Microarrays are already used extensively in studies of human and animal genetic variation and gene expression.

Portable DNA Typing Laboratory

Crime scene investigators are interested in onsite DNA testing. With the current ability to miniaturize laboratory components, some handheld or at least crime scene vehicle-based instrumentation will become available to type evidentiary material quickly at the crime scene. Such technology will never totally replace laboratory-based analyses because the environmental conditions at many crime scenes are not conducive to the efficient screening of evidence or for adequate contamination control.

Low Copy Number DNA Analysis

The ability to develop an STR DNA profile on items with very little DNA deposited on them, such as touched objects like a doorknob or drinking glass, is expected to aid in solving property crimes during which perpetrators have hot-wired a vehicle or stolen other property while bare-handed.

This type of analysis, called "low copy number" (LCN) DNA analysis, requires the same steps as standard STR testing but uses a higher number of PCR cycles to amplify the evidentiary DNA. The increased number of cycles produces more copies of the target DNA, making their STR typing more successful.

LCN protocols are currently in research and development stages.

Microbiology and Forensic DNA Typing

The online version of this course contains a multimedia [or downloadable] file. Visit this URL to view the file: http://beta.forensic.dna.devis.com/module15/3/default_page

Scientists apply the principles of forensic science to microbiology (the study of microscopic organisms) and microbial epidemiology (the study of disease-causing organisms in populations). DNA analysis differentiates strains of bacteria, viruses, and fungi, which are highly genetically diverse. Once a strain is fully characterized, tracking its origin may be possible by looking for sources with similar or identical DNA profiles.

*video courtesy of the University of Leicester Microbiology Video Library

Microbiology and Criminal Investigations

Microbiology and forensic methods are beginning to merge in criminal investigations. Consider the following potential scenarios:

- **Bioterrorism:** Individuals at multiple locations are exposed to anthrax. Can scientists identify the exact DNA strain and source of the *B. anthracis* used?
- **Suspicious death:** A hospital patient succumbs to a staphylococcal infection that could have been prevented by proper procedures. Where did the infection originate, and how was it transmitted?
- **Intentional infection:** One person intentially infects another person with HIV. Can the donor of the virus be confirmed by DNA typing of a specific viral strain?
- **Large-scale food poisoning:** Numerous individuals throughout a major U.S. city are hospitalized with food poisoning. Can the origin of an infectious agent such as *E. coli* or salmonella be found to prevent further outbreaks?

Forensic Principles and Practices Related to Microbial Investigations

In this developing field, scientists are working to be sure that forensic principles and practices are applied to microbial investigations:

- **Reliable evidence collection**: Appropriate and documented sampling of suspected microbial organisms from the crime scene.
- **Proper chain of custody**: Proper sealing of evidence and preparation and maintenance of records that trace the evidentiary material from crime scene to laboratory.
- **Correct laboratory analysis**: DNA analysis methods such as DNA extraction, PCR amplification, sequencing, STR analysis, SNP analysis, and others that have been validated by the laboratory.

Continued

Forensic Principles and Practices Related to Microbial Investigations (cont.)

- **Ongoing quality assurance and quality control**: Each laboratory shows that the methods being applied to microbial science are sound based on its records of successful routine analysis.
- **Supportable expert interpretation**: Conclusions drawn are supported by the data obtained in the analysis.
- **Courtroom admissibility**: The scientific methods must meet the *Daubert/FRE 702*, *Frye*, or other standards. 1

Analysis of Non-human Samples

Forensic DNA methods are being applied to criminal cases involving virtually any nonhuman source imaginable:

- Cat and dog hairs and bodily fluids may be associated with a crime.
- Fur, feathers, bone, blood, urine, feces, and saliva may link an animal to a poacher or verify illegal importation of animal products such as pelts or tusks.
- Meat products may be traced to cattle with mad-cow disease.
- Pods, seeds, leaves, bark, and roots of illegal plants or controlled substances, including marijuana may be present at a crime scene. Data collected from plants constitutes the newly emerging field of forensic botany. 2

Non-human Forensic DNA Analysis Applications

Domestic cat and dog samples have been used in several criminal cases nationally, usually to link a suspect to a pet. STR analysis has been used where animal blood, or hair with adequate root material, was available. Mitochondrial DNA (mtDNA) analysis has been used when hair without sufficient root material was available.

Continued

Non-human Forensic DNA Analysis Applications (cont.)

Although in most domestic species mitochondrial DNA typing lacks discriminatory power, it can be used as an exclusionary tool. STR analysis provides nearly the same discriminatory power in domestic animals as it does in humans, making an STR match very powerful where animals are involved.

DNA Typing and Physical Appearance

Issues will arise as to the usefulness, along with ethical and civil liberty questions, regarding the application of DNA analysis to predict physical characteristics of a perpetrator from DNA left at a crime scene.

Biogeographical Ancestry

Although controversial, a few laboratories are now predicting a person's biogeographical ancestry based on SNP markers that have been highly correlated with certain geographic regions.

For example, a crime scene sample showing genetic markers that have been specifically associated with individuals from a certain part of the world may suggest to crime investigators that a suspect may have features associated with that region.

Approximate Age Determination

A number of methods show promise for approximating an individual's age, including the detection of expressed age specific genes and damage to the genetic material.

Module Objectives Review

If you have successfully completed Module 15, you should be able to-

- Recognize some new forensic DNA technologies that are being developed.

You have successfully completed Module 15, Emerging Trends. This is the end of the course.

User Guide

This page provides an overview of interface controls that allow navigation between modules, topics, and individual pages. Descriptions of courseware icons and links are also included in this user guide.

User Guide

Navigating the Course

Section Tabs

There are 5 section tabs for navigating to different areas of the content:

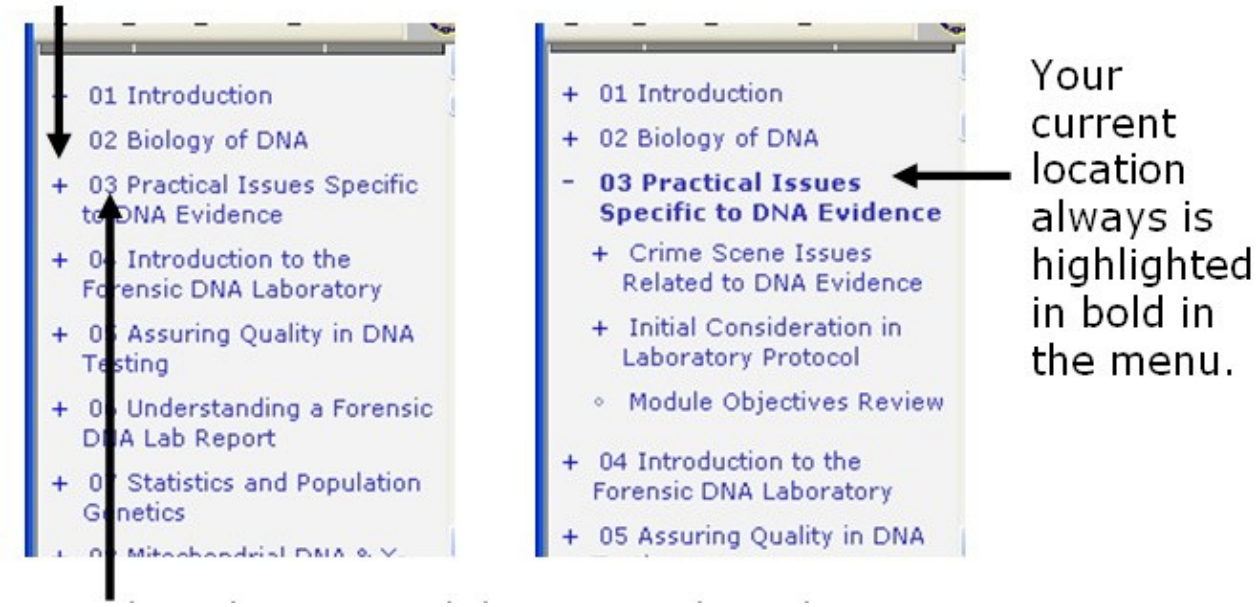
- Home—Return to the first page of the course. From this page you can easily skip to a new or return to a previous module/lesson. Your progress through the course is tracked so selecting module/lesson that you have already begun will return to to the last page viewed in that lesson/module.
- Glossary—A complete list of terms defined within this course and throughout DNA.gov
- Resources—A complete list of references from within this course.
- Help—Return to this page.
- Contact Us—Submit a question or comment about this course.

Page Navigation

Back and Forward arrows are available at the bottom of the content area to navigate from page to page.

Modules and Topic Menu Navigation

Select the '+' sign to expand the menu from any page to view all topics and sub-topics within a module while staying on the same page.



Go directly to a module or topic by selecting the title text. When a module is accessed, each Topic will appear below it within the menu.

What Icons Mean

Content Icons

4 icons signify what type of document they link to:

Gavel - case references

Bouncing ball - animations

Eyeglasses - flash paper documents and online links

Camera - plays a short video clip.

Sound and Captioning Icons

Sound Icon

Closed Captioning Icon

Most animations have sound (where appropriate) and contain text. These items can be turned off in most cases by clicking the sound icon or the closed caption (CC) icon as noted above.

Closing Pop-Up Windows

When certain links are selected (e.g., glossary terms, other Web sites) they open a new browser window. To close the new window and return to the previous page, just click the **X** in the upper right-hand corner.

System Requirements

to use all of the components of each module, the minimum system requirements are Flash 7 and either Internet Explorer 6 or Netscape 7, as well as a set of speakers or headphones.

Credits

To ensure that this program appropriately served its audience, a broad-based, multi-disciplinary focus group of subject matter experts was empaneled to develop content, multimedia, and user-interface components. Additional expertise from statisticians and researchers in the field of forensic DNA was obtained to provide the most accurate and comprehensive program content.

Special Thanks To

Sarah Hart
Director, National Institute of Justice (2001-2005)

Working Group Members

Jack Ballantyne
University of Central Florida

Susan M. Ballou
Office of Law Enforcement Standards
National Institute of Standards and Technology

The Honorable Ming Chin
California Supreme Court

The Honorable George W. Clarke
Judge of the Superior Court
County of San Diego

The Honorable Andre Davis
Judge, U.S. District Court
District of Maryland

Jules Epstein
Kairys, Rudovsky, Epstein & Messing

Debra Figarelli
City of Phoenix, Laboratory Services Bureau/
National Forensic Science Technology Center

Dean Gialamas
Forensic Science Services Division
Orange County Sheriff-Coroner Department

Syndi Guido
Office of Policy
Pennsylvania State Police

Carol Henderson
The National Clearinghouse for Science, Technology and the Law
Stetson University School of Law

Kimberly Herd
Office of the Assistant United States Attorney

Henry Lee
University of New Haven

Terry Melton
Mitotyping Technologies

Christopher Plourd
Law Office of Christopher J. Plourd

The Honorable Ronald Reinstein
Judge, Superior Court of Arizona

Steve Twist
National Crime Victim Law Institute

Subject Matter Expert Contributors

Frederick R. Bieber
Brigham and Women's Hospital

John Butler
Human Identity DNA Technologies Group
Biotechnology Division
National Institute of Standards and Technology

George Carmody
Carleton University

Joe Cecil
Federal Judicial Center

Greggory LaBerge
Denver Police Department Crime Laboratory

NFSTC Development Team

Robin W. Jones
Project Manager, Consultant

Mike O'Berry
Instructional Technology Manager

Eileen Fynan
Instructional Design Specialist

Mark Taylor
Multimedia Design Specialist

Danny Nichols
Multimedia Design Specialist

Module 5 Assuring Quality in DNA Testing

[1]*State v. Van Adams,* 984 P.2d 16 (Ariz. 1999); *Smith v. State,* 702 N.E.2d 668 (Ind. 1998); *State v. Ramsey,* 550 S.E.2d 294(S.C. 2001); *J.H.H. v. State*, 897 So. 2d 419 (Ala. Crim. App. 2004)

Module 10 Collection of DNA Evidence from Suspects and Arrestees from Suspects and Arrestees

[1]A grand jury subpoena has been allowed as a means of securing DNA evidence. *In re Shaddie Clark Shabazz,* 200 F. Supp. 2d 578 (D.S.C. 2002) (applying the "reasonable suspicion" standard to a Grand Jury subpoena seeking a DNA sample from a crime suspect).

[2]There is no Federal constitutional right implicated in seizing DNA evidence left in a public place. Several States have found searches of trash to be impermissible (if conducted without a warrant) under their respective State constitutions. Separately, some States apply a forced abandonment doctrine that precludes the seizure of items "abandoned" during an unlawful police chase. The United States Constitution does not bar use of such abandoned property. *California v. Hodari D.*, 499 U.S. 621 (1991).

[3] *Schmerber* v. *California ,* 384 U.S. 757 (1966) (the taking of a blood sample does not implicate the fifth amendment)

[4] *United States v. Wade,* 388 U.S. 218 (1967) (being forced to appear in a lineup does not violate the privilege against self-incrimination

[5] *Kirby v. Illinois,* 406 U.S. 682 (1972) (right to counsel at an identification procedure applies only "at or after the initiation of adversary judicial criminal proceedings—whether by way of formal charge, preliminary hearing, indictment, information, or arraignment").

[6] *Terry v. Ohio,* 392 U.S. 1 (1968).

[7] *Hayes v. Florida,* 470 U.S. 811, 817 (1985); *Davis v. Mississippi,* 394 U.S. 721 (1969).

[8] *Cupp v. Murphy,* 412 U.S. 291 (1973).

[9] *Kaupp v. Texas,* 538 U.S. 626, 630 n.2 (2003) ("We have, however, left open the possibility that, 'under circumscribed procedures,' a court might validly authorize a seizure on less than probable cause when the object is fingerprinting").

[10] *United States v. Edwards,* 415 U.S. 800, 806 (1974) ("When it became apparent that the articles of clothing were evidence of the crime for which Edwards was being held, the police were entitled to take, examine, and preserve them for use as evidence, just as they are normally permitted to seize evidence of crime when it is lawfully encountered.").

[11] *Schmerber* v. *California,* 86 S. Ct. 1826, 1835 (U.S. 1966) ("Serach warrants are ordinarily required for searches of dwellings, and absent an emergency, no less could be required where intrusions into the human body are concerned.").

[12] *United States v. Edwards,* 415 U.S. 800 (1974).

[13] *Winston v. Lee,* 470 U.S. 753 (1985).

[14] *Florida v. Jimeno,* 500 U.S. 248 (1991) (consent must be knowing and voluntary).

[15] *Florida v. Bostick,* 501 U.S. 429 (1991) (consent that is the product of an illegal arrest is generally invalid).

[16] *Florida* v. *Jimeno,* 500 U.S. 248 (1991).

[17] *Schneckloth* v. *Bustamonte,* 412 U.S. 218 (1973).

[18] *See United States* v. *Plotts,* 2003 U.S. App. LEXIS 21476 (10th Cir. filed October 22, 2003); *See Velasquez* v. *Woods,* 329 F.3d 420, 421 (U.S. App. 2003); *Shaffer* v. *Saffel* , 148 F.3d 1180, 1181 (10th Cir. 1998)

("while obtaining DNA samples implicates Fourth Amendment concerns, it is reasonable in light of an inmate's diminished privacy rights, the minimal intrusion involved, and the legitimate government interest in using DNA to investigate and prosecute crimes"); *Rise* v. *Oregon* , 59 F.d 1556,1559-62 (9th Cir. 1994) (same); *Jones* v. *Murry,* 962 F.2d 302, 306-308 (4th Cir. 1992)(same); *see also Roe* v. *Marcotte,* 193 F.3d 72, 78-82 (2d Cir. 1999) (compelled DNA testing valid under "special needs" exception to the warrant requirement); *but see United States* v. *Kincade,* 2003 U.S. App. LEXIS 20123 (9th Cir. filed October 2, 2003)(compulsory provision of DNA by convicted offenders and unconstitutional search in the absence of particularized reasonable suspicion; court also rejects); *United States* v. *Kincade* - note 379 F.3d 813.

[19] Statutes: Alaska R. Ct. 16(c)(1)-(2) (1988); Ariz. Rev. Stat. Ann. § 13-3905 (1978); Colo. R. Crim. P. 41.1 (1984); Idaho Code Ann. § 19-625 (1987); Iowa Code Ann. § 810.1-.2 (West 1978 and Supp. 1988); Neb. Rev. Stat. §§ 29-3301-3307 (1985); N.C. Gen. Stat. §§ 15A-271-282 (1983); Utah Code Ann. §§ 77-8-1-77-8-4 (1982).

Decisions: *In re Nontestimonial Identification Order Directed to R.H.,* 762 A.2d 1239 (Vt. 2000); *State* v. *Rodriguez,* 240, 921 P.2d 643, 650 (Ariz. 1996) (based on Arizona NTO statute); *People* v. *Madson,* 638 P.2d 18, 32 (Colo. 1981) (based on Colorado NTO rule); *Wise* v. *Murphy,* 275 A.2d 205, 216 (D.C. Ct. App. 1971); *Baker* v. *State,* 449 N.E.2d 1085, 1090 (Ind. 1983); *In re Fingerprinting of M.B.,* 309 A.2d at 7; *State* v. *Hall,* 93 N.J. 552, 461 A.2d 1155, 1160 (N.J. 1983); *In re Order Requiring Fingerprinting of a Juvenile,* 42 Ohio St. 3d 124, 537 N.E.2d 1286, 1288-89 (Ohio 1989) (based on Ohio statute allowing court to authorize photographing or fingerprinting of a juvenile).

[20] *Roberson v. State,* 16 S.W.3d 156 (Tex. App. 2000).

[21] *Stogner v. California,* 539 U.S. 607 (2003).

[22]*State* v. *Dabney,* 663 N.W.2d 366 (Wisc. Ct. App. 2003).

Module 11 Pretrial DNA Evidence Issues

[1] *Arizona v. Youngblood,* 488 U.S. 51, 58 (1988).

[2] *Brady v. Maryland,* 373 U.S. 83 (1963); *United States v. Agurs,* 427 U.S. 97 (1976).

[3] *Arizona* v. *Youngblood,* 488 U.S. at 56.

[4] *Illinois v. Fisher,* 540 U.S. 544 (2004).

[5] The States that have ruled that an individual need not demonstrate bad faith on the part of the State include: Alabama, *see Ex parte Gingo,* 605 So. 2d 1237 (Ala. 1992); Alaska, *see Thorne v. Dep't of Pub. Safety,* 774

P.2d 1326 (Alaska 1989); Connecticut, *see State v. Morales,* 657 A.2d 585 (Conn. 1995); Delaware, *see Lolly v. State,* 611 A.2d 956 (Del. 1992); Hawaii, *see State v. Okumura,* 894 P.2d 80 (Haw. 1995); Idaho, *see State v. Fain,* 774 P.2d 252 (Idaho 1989); Massachusetts, *see Commonwealth v. Henderson,* 582 N.E.2d 496 (Mass. 1991); Minnesota, *see State v. Schmid,* 487 N.W.2d 539 (Minn. Ct. App. 1992): New Hampshire, *see State v. Smagula,* 578 A.2d 1215 (N.H. 1990); New Mexico, *see State v. Riggs,* 838 P.2d 975 (N.M. 1992); Tennessee, *see State v. Ferguson,* 2 S.W.3d 912 (Tenn. 1999); Vermont, *see State v. Delisle,* 648 A.2d 632 (Vt. 1994); and West Virginia, *see State v. Osakalumi,* 461 S.E.2d 504 (W.Va. 1995).

[6] *Brady v. Maryland,* 373 U.S. 83 (1963); *United States v. Agurs,* 427 U.S. 97 (1976).

[7] *Brady* v. *Maryland ,* 373 U.S. at 83 (1963).

[8] *See, e.g*., Fed. R. Crim. P. 16(a)(1)(E), requiring production for inspection, on request, of "tangible objects…within the government's possession, custody or control…[where] item is material to preparing the defense…"

[9] Fed. R. Crim. P. 16(a)(1)(F). Similarly, discovery rules may require disclosure of summaries of expert witness testimony. Fed. R. Crim. P. 16(a)(1)(F).

[10] *United States v. Furguero,* 55 M.J. 525 (A.F. Ct. Crim. App. 2001).

[11] *State* v. *Proctor,* 348 S.C. 322 (S.C. App. 2001).

[12] *State v. Dunn,* 571 S.E.2d 650 (N.C. Ct. App. 2002).

[13] *Cole v. State,* 835 A.2d 600 (Md. 2003).

[14] *Frye v. United States,* 293 F. 1013, 1014 (D.C. Cir. 1923).

[15] *Daubert v. Merrell Dow Pharmaceuticals, Inc.,* 509 U.S. 579 (1993).

[16] *People* v. *Kelly,* 549 P.2d 1240 (Cal. 1976).

[17] Fed. R .Evid. 702.

[18] *General Elec. Co. v. Joiner,* 522 U.S. 136 (1997).

[19] *Rapp v. Singh,* 152 F. Supp. 2d 694, 699 (E.D. Pa. 2001).

[20]**Mitochondrial methodology generally accepted under *Frye* and *Daubert*:** *People v. Klinger,* 713 N.Y.S.2d 823 (N.Y. Co. Ct. 2000); *State v. Smith,* 100 Wash. App. 1064, *appeal denied,* 16 P.3d 1267 (Wash. 2000); *State v. Pappas,* 776 A.2d 1091 (Conn. 2001); *State v. Hammons,* 2001 Del. Super. LEXIS 545, 2002 WL 484645 (Del. Super. Ct. Mar. 28, 2002); *Magaletti v. State,* 847 So. 2d 523 (Fla. Dist. Ct. App. 2003); *State v. Scott,* 1999 Tenn. Crim. App. LEXIS 758, 1999 WL 547460 (Tenn. Crim. App. July 28, 1999), *reversed in part on other grounds,* 33 S.W.3d 746 (Tenn. 2000).

2.010a

DNA testing methodologies approved: Florida:*Brim v. State,* 779 So. 2d 427, 430 n.3 (Fla. Dist. Ct. App. 2000) (collecting cases approving DNA testing as satisfying the *Frye* or *Daubert* standards). *See generally* Edward J. Imwinkelried & D.H. Kaye, *DNA Typing: Emerging or Neglected Issues*, 76 Wash. L. Rev. 413, 457–458 (April 2001) (endnotes omitted) (“The opinions are practically unanimous in holding that the more commonly used PCR-based procedures satisfy these standards.”)

Statistical methodology generally accepted. *See generally* Edward J. Imwinkelried & D.H. Kaye, *DNA Typing: Emerging or Neglected Issues*, 76 Wash. L. Rev. 413 (April 2001); California:*People v. Soto,* 981 P.2d 958, 974 (Cal. 1999) ("[T]he controversy over population substructuring and use of the unmodified product rule has
dissipated."); Florida:*Brim v. State,* 779 So.2d 427, 430 n.4 (Fla. Dist. Ct. App. 2000) (collecting cases approving such probability testimony); Illinois: *People v. Miller,* 670 N.E.2d 721, 731-32 (Ill. 1996) ("While there has been some controversy over the use of the product rule in calculating the frequency of a DNA match, that controversy appears to be dissipating."); Maryland: *Armstead v. State,* 673 A.2d 221, 238 (Md. 1996) ("The debate over the product rule essentially ended in 1993."); Massachusetts:*Commonwealth v. Fowler,* 685 N.E.2d 746, 748–750 (Mass. 1997) (product rule now meets test of scientific reliability in light of 1996 NRC Report).

[21] *Murray v. State,* 838 So.2d 1073, 1077 (Fla. 2002).

[22] *People v. Pizarro,* 3 Cal. Rptr. 3d 21, 143 (Cal. Ct. App. 2003) (although RFLP analysis has met the *Frye* test, a specific RFLP procedure using “band intensity” analysis had not been shown to satisfy *Frye* and thus its results were inadmissible).

[23] *Ake v. Oklahoma,* 470 U.S. 68, 77 (1985).

[24] 470 U.S. at 79.

[25] For a detailed survey of this issue, see John Devlin, Comment, *Genetics and Justice: an Indigent Defendant's Right to DNA Expert Assistance,* 1998 U. Chi. Legal F. 395.

[26] *Dubose* v. *State,* 662 So.2d 1189, 1197 (Ala. 1995). *See also Cade* v. *State,* 658 So. 2d 550 (Fla. App. 1995) (requiring the provision of expert DNA assistance where DNA is central to the case and the evidence of

guilt is otherwise not overwhelming); *State* v. *Scott,* 33 S.W.2d 746 (Tenn. 2000) (finding DNA expert assistance part of the "basic tools of an adequate defense"); *Sanchez* v. *Commonwealth,* 585 S.E.2d 327, 332-333 (Va. App. 2003) (where initial funding of expert generated report that prosecution expert had made errors, lower court erred in denying funds for defense expert to testify at trial).

[27] *People v. Tanner,* 671 N.W.2d 728 (Mich. 2003) (no error in denying defense DNA expert where prosecution DNA evidence showed that defendant was not the source of crime scene DNA and counsel made no showing as to how an expert would otherwise assist the defense); *Husske v. Commonwealth,* 476 SE.2d 920, 926 (Va. 1996), *cert. denied,* 519 U.S. 1154 (1997) (denial upheld where defendant failed to make particularized showing of the need for expert assistance); *Mosier v. State,* 462 S.E.2d 643, 647 (Ga. Ct. App. 1995) (“Mosier failed to show what his expert proposed to do regarding the evidence and failed to advise the court of the anticipated cost of these services.”).

[28] *Leonard v. Michigan,* 287 F. Supp. 2d 765, 790–792 (W.D. Mich. 2003).

Module 13 Trial Presentation

[1] Jason Schklar & Shari S. Diamond, *Juror Reactions to DNA Evidence: Errors and Expectancies, in* 23 Law & Hum. Behav. 159 (1999).

[2] See *Murray v. State,* 838 So. 2d 1073 (Fla. 2002) (DNA testing procedures were sufficiently flawed to be inadmissible under Frye).

Module 14 Postconviction DNA Cases

[1] Testing under category 3 circumstances would encompass circumstances not encompassed by 18 U.S.C. § 3600, which states “DNA testing of the specific evidence that may produce new material evidence that would (A) support a theory of [an affirmative] defense [presented at trial] and (B) raise a reasonable probability that the applicant did not commit the offense."

Module 15 Emerging Trends

[1] *Frye v. United States,* 293 F. 1013 (D.C. Cir. 1923); Daubert *v. Merrell Dow Pharmaceuticals*, 509 U.S. 579 (1993); Fed. R. Evid. 702.

[2] *State v. Bogan,* 905 P.2d 515, 518 (Ariz. Ct. App. 1995).

Feedback for the Course

Thank you for your interest in the *Principles of Forensic DNA for Officers of the Court* training course. We are very interested to receive feedback from our users, whether it's ways to improve the course, things you liked/disliked, or any problems you encountered along the way. Please take a moment to fill out the following Feedback Form.

Personal Information (optional)

First Name:

Last Name:

Email address:

Comments
(required)

Thank You

We appreciate you taking the time to submit your comments on *Principles of Forensic DNA for Officers of the Court*

Contact Us

Website and Course Questions

If you have a technical question about the Web site or this course, please contact DNA.gov Training Site Assistance.

General DNA Questions

If you have a question about DNA or need additional material, please contact Ask DNA.gov.