

# NATIONAL JUVENILE DEFENDER CENTER

## *\*\* Fact Sheet \*\**

### DNA EVIDENCE

#### *Part 1: A Scientific Explanation for Lawyers*

##### *What is DNA?*

DNA is the genetic material that exists in the cells of every living organism. Humans have two copies of their genetic material in each cell. One copy is inherited from the mother; the other copy is inherited from the father. While nearly all DNA is exactly the same in every human, there are some areas in human genes where differences occur. Indeed, there is sufficient variation so that, with the exception of identical twins, every person's DNA is unique.

DNA is a double-stranded molecule shaped like a long, twisted ladder. It is made up of strands of organic bases that form the ladder's "rungs." Each rung is made up of two bases (referred to as a base pair). These long strands of base pairs make up human genes. In a human, most of the ladder looks exactly the same as in all other humans. There are areas in every human, though, where the bases that make up the rungs of the ladder differ from person to person. For example, one would not expect that the area on a DNA strand that determines eye color would look the same for every person. Otherwise, everyone would have the same color eyes.

##### *What does Forensic DNA Testing Do?*

DNA testing is designed to highlight the differences in each person's genetic material in order to determine whether an unknown physical sample (such as blood, hair, etc..) could have originated from a known person (such as a suspect, victim, or bystander). There are two steps that must be taken in order to make such a determination:

1. First, scientists must compare the DNA of the known person and the unknown sample to determine whether or not they are alike. To do so, scientists must highlight the areas on DNA that differ from person to person (such as eye color). Each test must highlight several areas; it is not enough to look at eye color to establish that a blood sample found at a crime scene belonged to a suspect; many people have the same color eyes. It is far less likely that a person will have blue eyes, brown hair, and will be tall. As the number of traits increases, the less likely it is that the combination of traits will appear in any given human. If a scientist discovers that a significant number of traits are identical in two samples, he/she will declare that the two samples are

a 'match,' meaning that they originated from the same person.

2. The next step in DNA testing is to put the scientist's findings into context. DNA testing is based on the premise that when a sufficient number of traits are found to be identical in two different DNA samples, the likelihood that the two samples originated from two different individuals becomes extremely low. Thus, after DNA has been tested, statisticians analyze data from the general population to establish the likelihood of two people having the same traits. This second step is the reason why DNA experts in the courtroom can make declarations such as, "the likelihood of such a match is 1 in 1 billion."

##### *How Does DNA Testing Work?*

DNA is much too small to be seen by the naked eye so scientists must use tests to create visual representations of DNA. Once a visual representation has been made, it can be compared to another visual representation in order to determine whether the two 'match.'

##### *What are the Different Types of DNA Tests?*

There are several different types of DNA testing in use today, each of which has its own level of reliability, specificity and appropriateness. It is generally up to the forensic scientist to determine which method is best in a given situation. It is important that criminal defense attorneys are familiar with these different methods:

##### *Restriction Length Polymorphism Fragment (RPLF) Analysis:*

###### *❖ Background Information:*

RPLF is the most widely accepted and, until recently, the most common testing method used in the United States. When done properly in the presence of a large sample, it is very accurate. However, it cannot be done when a sample is too small or if it has been degraded by exposure to sunlight, moisture, chemicals or other elements. It is also time consuming, and can take several months to complete.

###### *❖ The RPLF Testing Procedure:*

1. DNA is extracted from samples such as blood.
2. After extraction, scientists subject the DNA to 'restriction enzymes', chemicals that bind to specific areas on the DNA and cut the strand into smaller pieces. Because the restriction enzymes are designed to target areas on the DNA that differ

among humans, the size of each cut piece will vary from person to person.

3. In the next steps, the fragments obtained during the first part of the DNA test are measured. The relative sizes of the fragments are used to create a visual representation of the DNA.
4. To do so, the pieces are subjected to a process called electrophoresis, in which they are placed in a gel and charged with an electric current. The current draws the fragments through the gel in a sort of DNA race. Smaller, lighter pieces will move faster through the gel than larger, heavier pieces and thus will travel farther. Scientists will use these relative distances to create a visual representation of the DNA that will help them to distinguish differences between the fragments.
5. The next step is to create a blot, or replica of the gel that will capture the positioning of each fragment. Scientists then attach probes to the fragments that will help them recognize the position of each piece. Using the probes, scientists read the length of each piece and use their data to draw a "picture" of each fragment.
6. The result is a row of bars of various sizes and positions that can be compared with a known sample (taken from the blood of a possible suspect or from the victim). The comparison can be done with the help of a computer.

### ***The Polymerase Chain Reaction (PCR) - Based Analysis:***

#### **❖ Background:**

The term PCR is used to describe a variety of different DNA tests that vary in reliability and effectiveness. These various tests are similar in that they all begin with the PCR procedure. PCR is not actually a testing method but a way to increase the size of a very small or degraded sample of genetic material so that it can be tested. PCR can therefore allow forensic experts to analyze a sample of DNA that is much smaller and more degraded than RFLP testing. It is also significantly faster and less expensive. However, the PCR procedure

is especially sensitive to contamination. If even a small amount of outside DNA is in the original sample, PCR can amplify it significantly and skew testing results. Once the PCR procedure is performed, the samples are tested in a variety of different ways, each of which varies in its level of acceptance and reliability.

#### **❖ The Science:**

1. DNA extracted from a sample is heated with a mixture of enzymes. In the presence of heat and enzymes, the double-sided strands that make up DNA molecules split into single strands (picture a ladder cut in half lengthwise).
2. When the mixture is cooled, bases that have been added to the solution (called primers) bond onto specific target areas on the "unzipped" DNA strands. The purpose of these primers is to "mark" the DNA.
3. An enzyme called Taq DNA polymerase is added and the temperature is increased so DNA fragments floating in the solution attach themselves to the primer marked strands of DNA. Thus, new double strands are formed, and the solution contains twice as much genetic material as it originally had.
4. The PCR process is repeated roughly thirty times to produce billions of copies. Once the copies are made, forensic scientists use a number of testing methods to find DNA matches.

### ***Mitochondrial DNA Testing (mtDNA):***

#### **❖ Background:**

The DNA used in most forensic tests is extracted from the nucleus of a cell. DNA is also found in a cell's mitochondria. Mitochondrial DNA (or MtDNA) testing extracts DNA from the cell's mitochondria. Although mtDNA is much smaller than the DNA found in a cell's nucleus, the number of mtDNA in a given cell is far greater. Thus, when a sample found at a crime scene is very small, extremely degraded, or if it comes from bone or hair, mtDNA testing may be appropriate. Because mitochondrial DNA is inherited differently than nucleic DNA, mtDNA profiles are identical to all persons maternally related to the contributor. Thus, mtDNA testing is not necessarily able to eliminate members of the same family.

❖ **The Science:**

Forensic scientists use the above-described PCR methods for multiplying and then testing mtDNA.

***What are the Problems Associated with DNA Testing?***

The scientific community recognizes the theory underlying DNA testing as valid. Controversy surrounds factors such as the accuracy of labs used, interpretation of DNA testing results and human error.

**Problems with Testing and Testing Analysis:**

Some of the problems with particular tests are discussed above. However, there are some problems that are common among all DNA tests.

- *There is always a potential for human error or contamination in collection and testing of DNA.* Samples must be moved from the crime scene to the lab, usually changing hands several times and creating numerous places in which contamination could occur. Crime labs themselves may fail to take proper precautions when testing, a problem that may result in a false positive reading.
- *Interpreting the results of DNA analysis is a subjective process.* At the end of a test, forensic scientists are presented with two sets of markings - one of the sample collected from the crime scene and the other a known sample (eg. the victim or a suspect). Using computer scoring, they must arrive at one of three possible conclusions - that the sample is a match to a known sample, a non-match or that the tests were inconclusive. This method of scoring is neither consistent from lab to lab nor always accurate. Results that seem clear to one person may seem ambiguous to another. Despite these problems, when a lab presents a final report to a client, it simply makes a determination of match, non-match or too close to call and does not report whether there was any ambiguity in interpreting the results.
- *Lab technicians are often aware of the law enforcement's theory of the case when administering DNA tests.* This knowledge can skew the technician's interpretation of the results if the test. In the past several years, members of the scientific community have

pushed for blind scoring in order to eliminate any potential bias, but it is not required.

**Problems with Statistical Analysis:**

A DNA "match" is meaningless unless it can be shown to be a statistically rare event. DNA is effective in the courtroom because expert witnesses offer impressive statistics such as, "the chances of such a match are one in one billion." But these numbers can come out very differently depending on who does the math. There are two types of statistics for the statistician to review. First, the statistician must evaluate the chance of a coincidental match (the chance that two people have the same traits that were examined during DNA testing). Second, the statistician must estimate the likelihood of a laboratory error. This second probability is often overlooked. However, the likelihood of a laboratory error is usually far greater than the likelihood of a coincidental match, and is therefore more persuasive to juries.

- *Probability of a Coincidental Match:* In order to arrive at their figures, statisticians compare DNA test results to databases comprised of random DNA samples extracted from the general population. Scientists use these databases to calculate the likelihood that two people will have the same genetic traits. This procedure can be problematic depending on the database used to make the calculations. There is significant debate within the scientific community as to whether it is necessary to account for similarities within racial and ethnic groups when calculating statistical evidence. The NRC II Report suggested that juries should be presented with evidence that has been compared with members of the defendant's sub-population group whenever possible. Therefore, if the defendant is Chinese, he/she should be compared with other Chinese people in the U.S., rather than the population as a whole. Another set of problems arises when the case involves a close relative. Relatives are much more likely to have traits in common with each other than with the rest of the general population. If possible, each relative should be tested and compared against each other and the known sample - rather than basing probability calculations on a database. If comparison testing cannot be done, special formulas must be used in calculating probability for family members.
- *Probability of Laboratory Error:* Although no

court requires it, many experts argue that juries should be presented with evidence of the likelihood of a false positive reading of their DNA tests. Unfortunately, there is no nationally recognized, standardized data with which to compute the probability of laboratory error; it therefore must be handled on a case by case basis. One way to calculate the error rate is to examine proficiency tests done within a particular lab (although proficiency testing itself is not standardized, and the method used for proficiency testing should also be scrutinized).

***Conclusions:***

Most defenders believe that it is virtually impossible to win a case that involves DNA evidence against a defendant. However, DNA evidence is not infallible. There are many points in both the scientific and legal processes in which the validity of DNA evidence can be brought into question. Our next fact sheet will examine how to take on a DNA case from a legal perspective, offering tips on what to do before trial, how to deal with a prosecution's expert witness, and how to convince a jury that DNA evidence is not a forgone conclusion.

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