

DNA: Everything you know you learned from CSI

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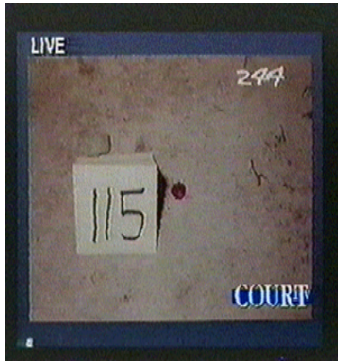
DNA/CSI Quiz

True or false:

- DNA results take 8 minutes
- DNA results can tell investigators what a suspect looks like
- DNA results can determine guilt or innocence
- CSIs are all ridiculously good looking and solve crimes wearing Armani
- All CSI drive Hummers, especially in Florida



Importance of Forensic Evidence

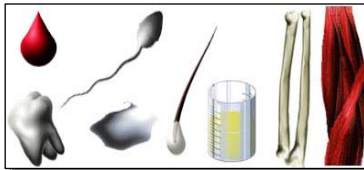


- An extremely strong link between the victim and suspect
- Correct scientific evidence is extremely difficult to dispute by the defense
- It may help not only the immediate case, but other possible connected cases

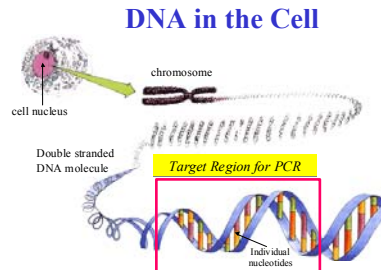
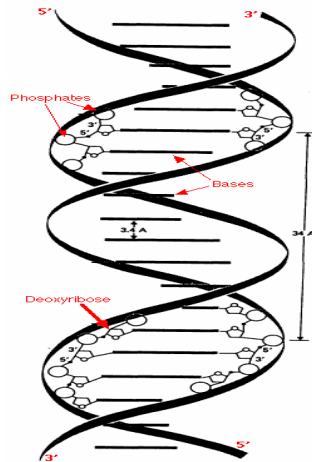
DNA can be found in a variety of places

Sources of Biological Evidence

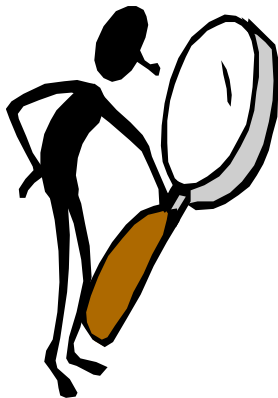
- Blood
- Semen
- Saliva
- Urine
- Hair
- Teeth
- Bone
- Tissue



Structure of DNA



Importance of Proper Collection



- Prevents loss of evidence
- Prevents contamination of the evidence
- Provides documentation to support testimony in a court of law

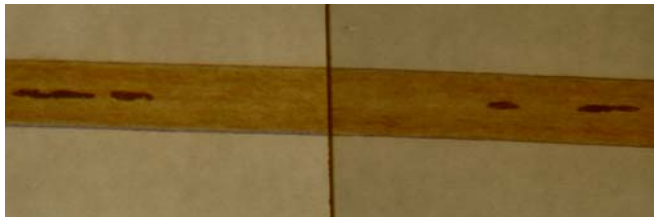
Contamination - Issue or not

- One piece of DNA is copied 3 billion times in the PCR process
- Laboratory analyzes only 2 ng of DNA in PCR reactions
- **Definitely an issue!**



Trace evidence - Hair and Fibers

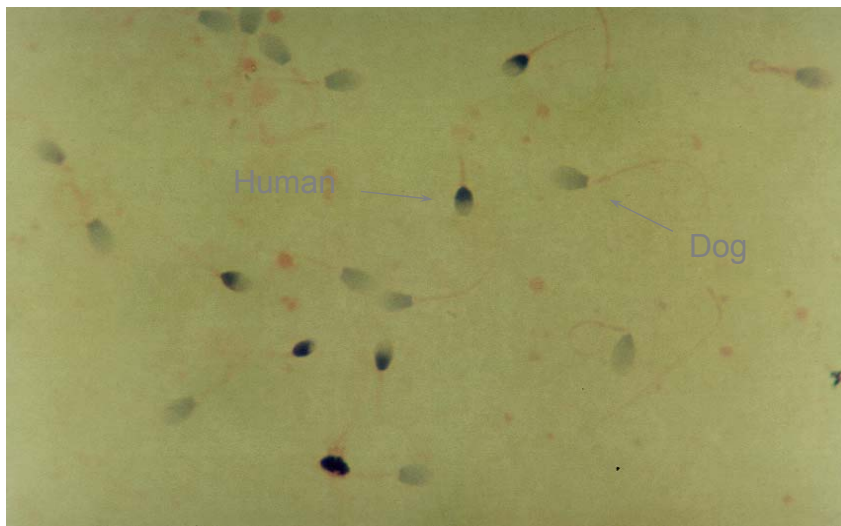
- Can be easily lost or missed
- Good supportive evidence
- The laboratory's first line of analysis is DNA, then we will evaluate the trace evidence



Identification of Semen

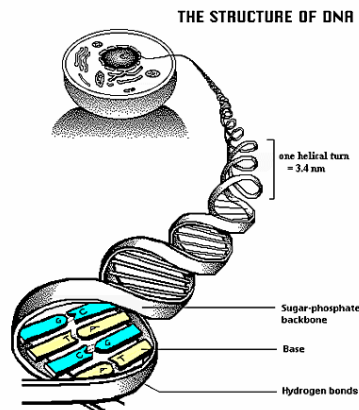
- Primary indicator of sexual activity
- Begin with the vaginal swabs and work our way out
 - Vaginal swabs, external swabs, underpants, sheets, bedding, other
- With successful analysis of semen, limited further analysis will be performed

Different issues in cases



Forensic DNA Analysis

- DNA is an extremely robust chemical molecule
- High degree of probability
 - Statistics of 1 person in 2 quadrillion Forensic databases
 - National comparison of profiles



Differential Extraction

- Vaginal swabs will have a mixture of female fluid and semen
- Lyse the epithelial (skin) cells first
- Remove supernatant containing female (epithelial cells) portion
- Lyse sperm cells
- From a single exhibit you now have two samples for DNA testing

Different Types of Evidence



- Condoms thrown in trash, on floor, in toilets, in pockets!

How DNA is used to identify individuals

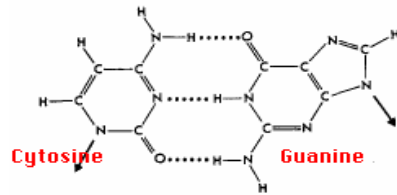
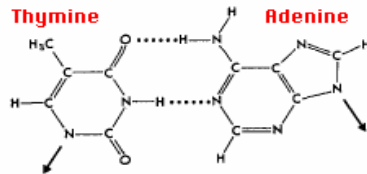
DNA molecule is ideally suited to forensic typing because of its polymorphic nature (different forms of the same structure, variations of base pair sequences within the DNA molecule)

Variable number of tandem repeats (VNTRs)

What varies within DNA?

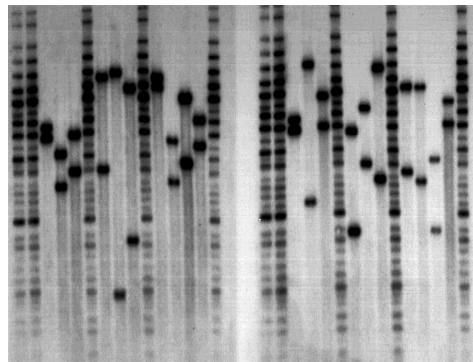
Order of the sequence of the amino acid building blocks which are structured in pairs

A-T
G-C



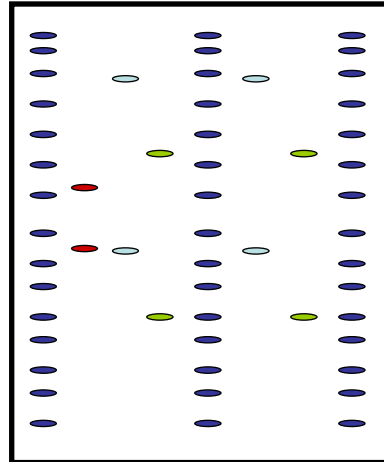
Restriction Fragment Length Polymorphism (RFLP) Technique

- First testing done by Forensic Laboratories
- Evaluated 5 different genetic loci and Y-specific marker
- No public laboratory performs this analysis anymore



Statistical Determination

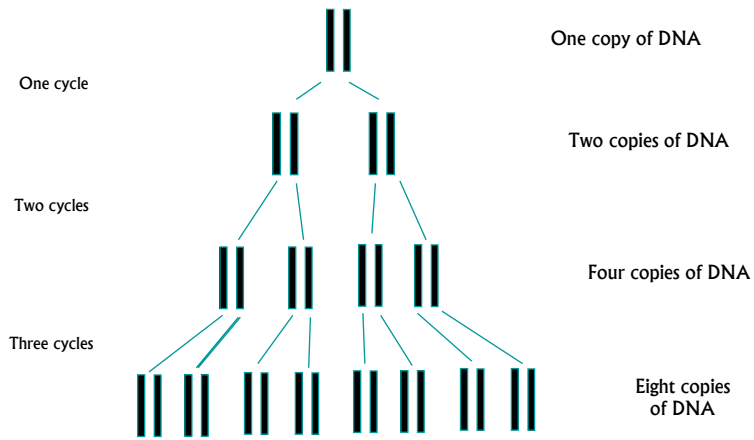
- Match at 1st genetic locus = 1 person/100
- Match at 2nd locus = 1 person/50
- Multiply each together = 1 person/5000
- 5 loci gives statistics of 1 person/5 million



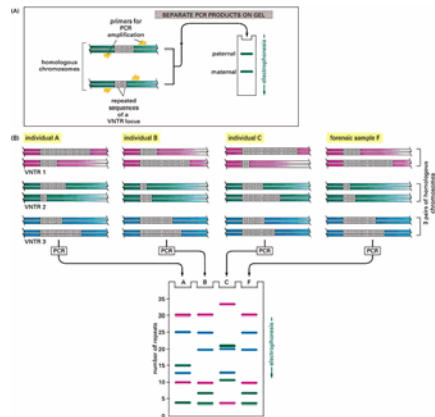
Polymerase Chain Reaction (PCR)

- Allows us to analyze extremely small samples
 - semen from vasectomized males, saliva from bite marks, etc.
- Quicker turn around times on results
- Used on most DNA testing conducted by forensic laboratories
- Limited amount does not mean miracles

Polymerase Chain Reaction (PCR)



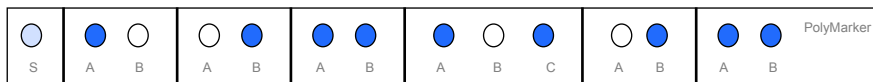
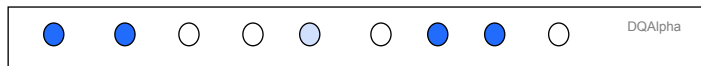
PCR process cont'd



Types of analysis by PCR

- DQ α - PolyMarker
DQA1-PM
- Short Tandem
Repeats
STR's

DQ α - PolyMarker



- Limited statistics, difficult to interpret mixtures
- No longer performed by any forensic laboratory

Reverse Dot Blot

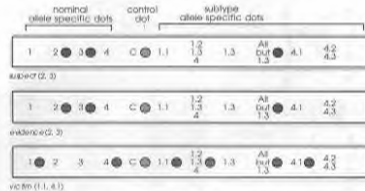


Figure 5.4 Representation of a DQA1 reverse dot blot. A total of 11 probes are present on each strip. In this case, the suspect and evidence samples show an identical pattern of dots, while the victim sample shows a different pattern. The "C" dot is a control probe that shows up regardless of DQA1 type. The dots to the left of "C" (1, 2, 3, and 4) give the nominal allele designations; the dots to the right of "C" are used to determine some of the subtypes into which the 1 and 4 alleles can be subdivided. The DQA1 system is able to distinguish the 4.1 subtype from the nominal 4 allele, an improvement over the D2S system. Interpretation of DQA1 results is discussed further in Chapter 7.

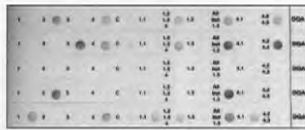
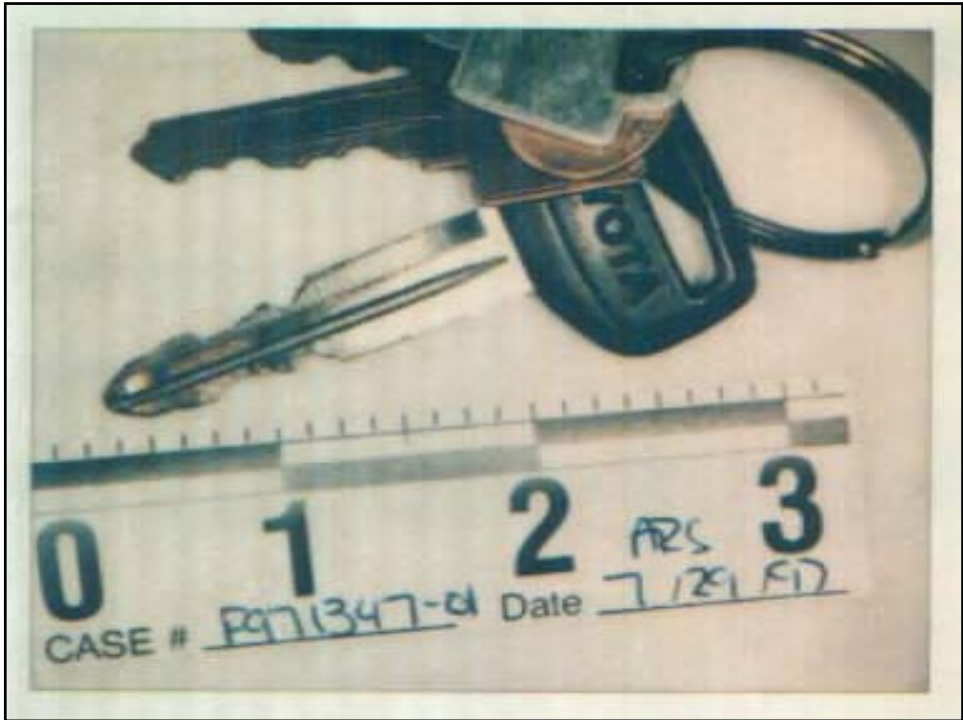


Figure 5.5 A DQA1 reverse dot blot. Above are five typing strips, each representing a different individual.

Case Example

- Female jogger attacked and killed on the trail
- LE thought maybe she had fought attacker with her only weapon - her keys
- Lots of blood on the scene
- Importance of reconstructing the crime and prioritizing probative evidence





Evidence

- 01 – Victim's keys
- 02 – Blood on leaf
- 03 – Blood on stick
- 04 – Blood on stick
- 05 – Victim
- 06 – Suspect

What results would you expect?

| | LDLR | GYP A | HBGG | D7S8 | GC | DQA1 |
|-------------------|-----------|-----------|----------|----------|-----------|-----------------|
| 01 Keys | B | AB | B | A | C | 1.2, 1.3 |
| 02 Blood on Leaf | <i>AB</i> | <i>AB</i> | <i>B</i> | <i>A</i> | <i>AC</i> | <i>1.2, 4.1</i> |
| 03 Blood on stick | B | AB | B | A | C | 1.2, 1.3 |
| 04 Blood on stick | <i>AB</i> | <i>AB</i> | <i>B</i> | <i>A</i> | <i>AC</i> | <i>1.2, 4.1</i> |
| 05 Victim | <i>AB</i> | <i>AB</i> | <i>B</i> | <i>A</i> | <i>AC</i> | <i>1.2, 4.1</i> |
| 06 Suspect | B | AB | B | A | C | 1.2, 1.3 |

STR Silver Staining

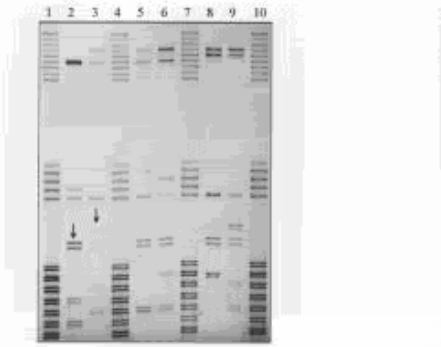
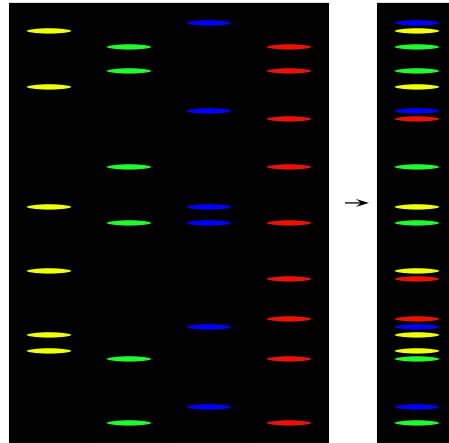


Figure 5.9 An STR silver-stained gel. Lanes 1, 4, 7, and 10 each contain a mix of the allelic ladders to which all questioned samples are compared. In this case, three loci have been analyzed simultaneously; thus, three distinct sets of non-overlapping bands are present in each vertical ladder lane. Lanes 2, 3, 5, 6, 8, and 9 each contain samples from a single individual. Each band is compared directly to one in the ladder lane, thus establishing the allele present in the sample. Note that all bands appear as doublets in the lower part of the gel; the reason for this is discussed in Chapter 7. In addition to the three multiplexed STR loci, the gender identification locus has been added to this system. In each sample lane (but not in the ladder lanes), either one or two doublets (see arrows) are present in the vertical space between the middle and bottom sets of STR allelic ladder bands. One doublet indicates a female (lane 2); a pair of doublets indicates a male (lane 3).

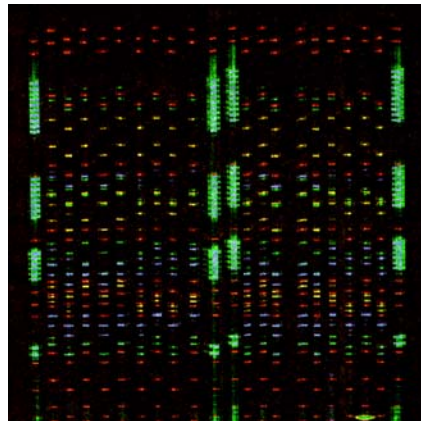
PCR-STR DNA Technique

- Attach to each piece of DNA a different color tag
- Analyze four colors at the same time
- Nine different loci with the degree of discrimination in the quadrillions

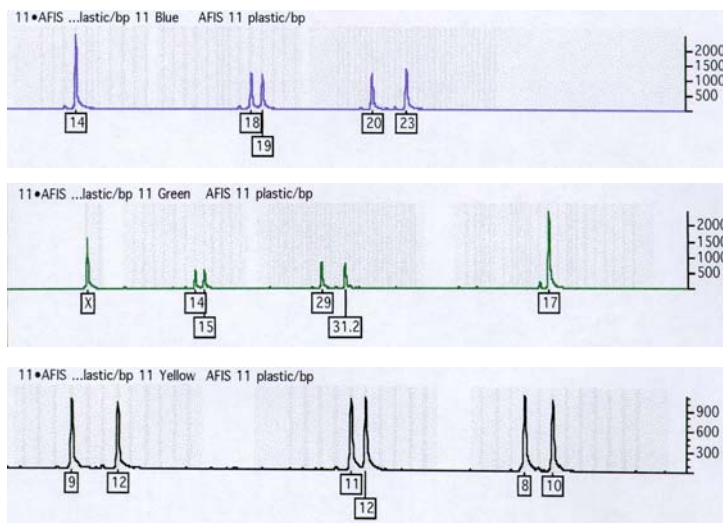


PCR-STR DNA Technique

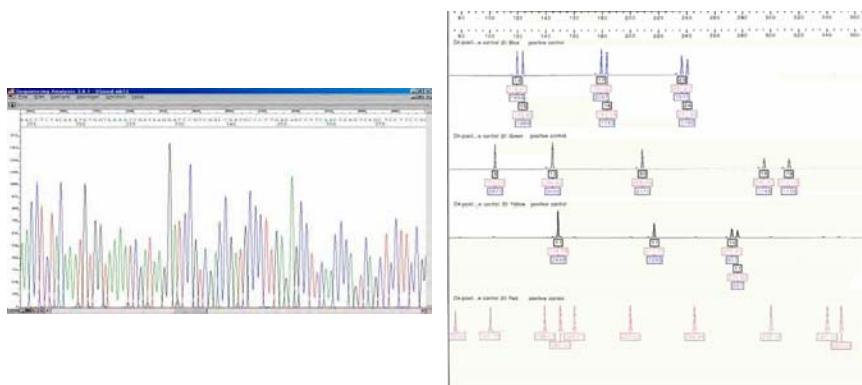
- Latest technology used by all laboratories
- Automated
- Allows you to analyze up to 16 different genetic loci simultaneously



Techniques are rapidly advancing.

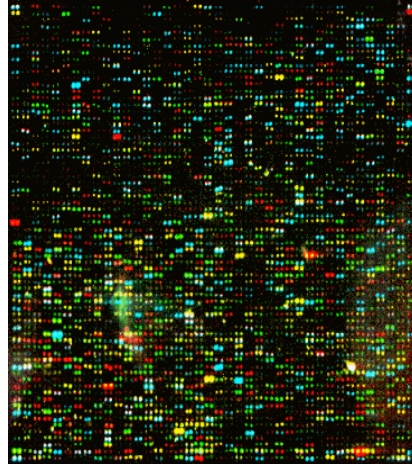


Multiplex STR

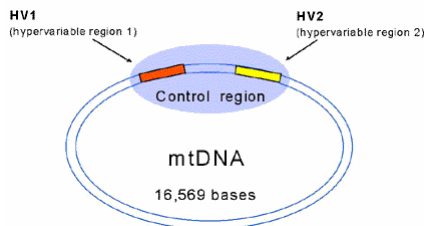


SNPs

Single nucleotide
Polymorphisms
Used in WTC, Pentagon
disasters to identify
victims and match
remains

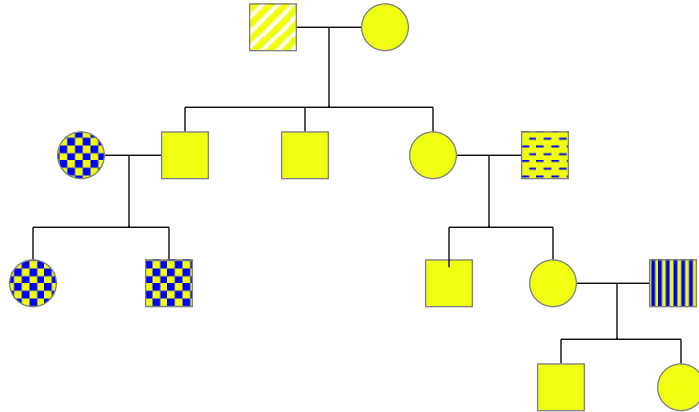


Mitochondrial DNA Analysis



- Highly specialized analysis
- Good for bones and hair shafts
- Only a few laboratories perform the analysis -FBI, Armed Forces laboratory, and a few private labs.
- Cost - \$2000

Maternal Inheritance



Y STRs

- Y Chromosome only
- Can resolve multiple male mixtures
- Can identify DNA from male contributor even in absence of sperm

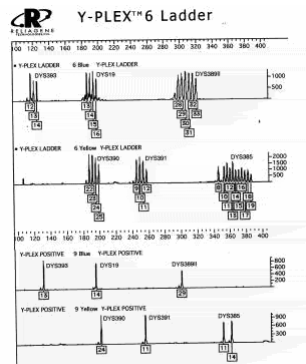


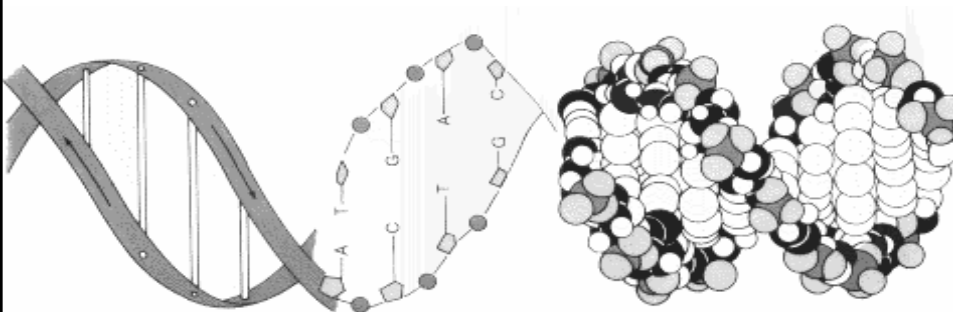
Figure S-14 A Y-STR allelic ladder and sample. The Y chromosome of males contains STR loci that can be analyzed in the same fashion as STR loci on the autosomal chromosomes. Because the Y chromosome has no homologous, these loci show only one peak per male sample. The Redtag® Y-PLEX™ 6 kit types six different Y-STR loci. The top two panels contain the allelic ladder, similar to those explained in Figure S-11. The bottom two panels contain a sample from one person. (Courtesy of Redtag Technologies, Inc.)

The Future of DNA Analysis



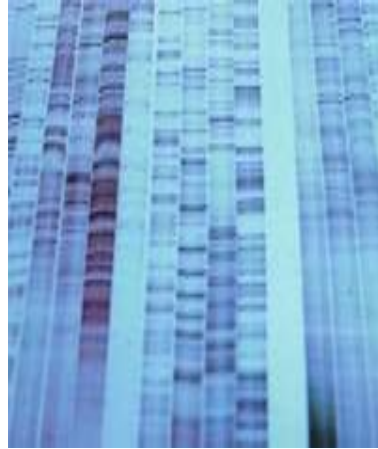
The DNA Wars, a Brief History

Although now widely accepted, it was not always so...



Methodology Challenges

- RFLP testing was subjected to *Frye* hearings when first proffered late 1980's
 - Challenges to:
 - Methodology
 - SOPs
 - Whether mistake had been made in the instant case
- This was expected



People v Castro

- People v Castro 144 Misc.2d 956, 545 N.Y.S.2d 985 (1989)
- NY Frye state, but court took a more conservative approach
- Required general acceptance + a determination that lab properly applied the technique on each particular occasion
- Excluded evidence of match of 1 in 1 billion frequency estimate

General Acceptance

- Forensic DNA evidence was offered under the aura of expert testimony and was initially generally accepted
- Eventually, defense attorneys began to challenge it
- Found that there was disagreement over the methods used to calculate statistics assigned to genetic profiles

The DNA Wars

Disagreement over the admissibility of statistical calculations assigned to the genetic profiles used for human identification provided valuable lessons for later forensic disciplines



General Acceptance (cont'd)

- Statistics did not affect the actual methods used to generate the genetic profiles
- They affected the weight the results were afforded at trial
- Scientists agreed that they may have rushed to court too quickly, but only needed to reevaluate the calculations, not the testing itself

Controversy over Statistics

2 sides to the numbers:

- “big is big”
- calculation should be accurate/exact

Scientifically or statistically significant vs.
legally significant

Interim Solution: NRC I

- National Advisory Group convened by National Academy of Science to draft recommendations on testing and reporting to the field
- Issued report in 1992

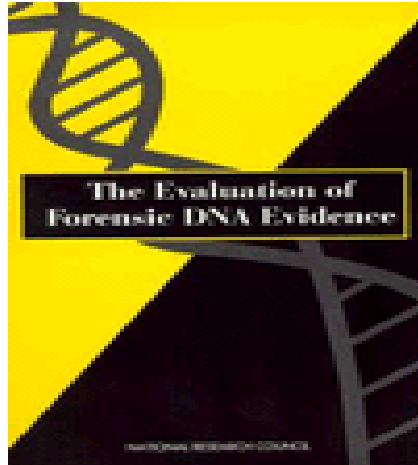


Validity - Counterarguments

- Methods used by DNA analysts are basic molecular biology techniques
- Used for decades for medical and disease research
- Only their *application* to human identification was new

Solution: NRC II

- Convened to resolve issues of statistical calculations
- Issued report in 1996 with amended recommendations on calculating statistics to account for potential subpopulation variations



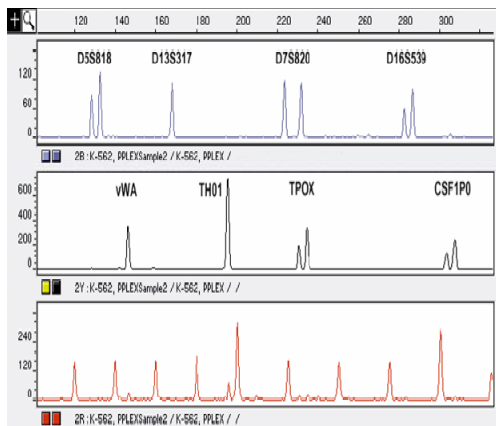
DNA- “New” Challenges

With the statistics issue resolved, and the testing methodologies becoming generally accepted, challenges moved toward individual cases:

- Analysts qualifications
- SOPs
- Potential mistakes in the instant case

What qualifies as “new”?

- Technology evolves
- Scientific vs. legal definition of what is truly “novel”
- PCR testing was challenged each time new probes were available



PCR Testing cont'd

- As testing became more widespread, more money was put into research to make it better, faster, cheaper, more discriminating
- Each iteration of new tests were viewed by the legal community as “new” and therefore subject to new challenges



Primer Sequences, do they Matter?

- Clever legal argument set DNA testing back
- Commercial entities claimed IP rights, refused to disclose data
- Difficulty of trying to explain complex scientific processes to those with little or no scientific background
- Knowing you're right doesn't matter when someone else is ruling
- Eventually overcame (and rendered argument obsolete)

Authentication



How do you prove that the DNA detected and reported *actually* came from the event in question and was not planted, fabricated or misinterpreted by the analyst?

Interpretation

- In addition to questionable statistics, results can be misrepresented in testimony
- Terminology matters ('consistent with', 'cannot be excluded' vs. 'identity', 'it's him')
 - May mean the same thing to a scientist, but not to a fact finder...

Admissibility

Testimony can be wholly excluded if found to be overly prejudicial, or can be admitted with vigorous cross examination in hopes that the fact finder will afford it less weight.

How do we know we're getting our point across?

Verdicts

How DNA helps solve crimes

National (and International) searchable
Database

Often casually mentioned on TV shows like
CSI

Rape in the United States

Reported to Police

| | 2002 | 2003 |
|------------------------------|---------------|---------------|
| Rape / Attempted Rape | 95,235 | 93,433 |
| Cleared by Arrest | ND | 42% |

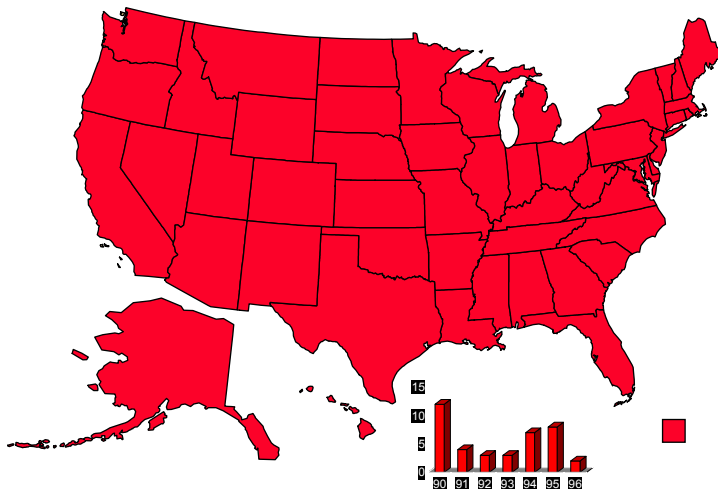
What do you do when there is no suspect?

Source: "Crime in the United States, 1984-
2003" Uniform Crime Reports; 2004

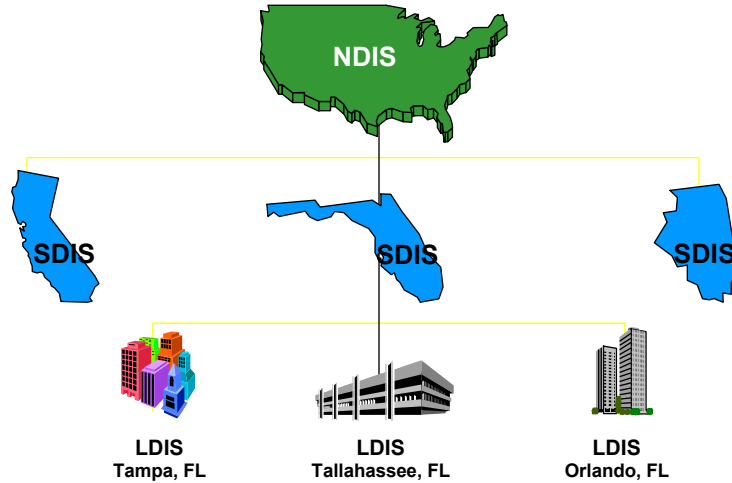
What can be done about it?



States with Offender Legislation Including 2 Federal laboratories



CODIS Architecture



How does it work?

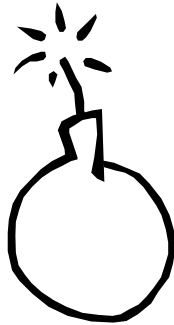
- DNA profile is developed from the semen sample
- Profile is placed in the CASEWORK database

Search is performed to see if any samples with in the database match

Case work database

Contains DNA profiles generated from case analysis. These samples are from “unknown” samples

Match between 2 casework samples



- Unsolved case to unsolved case
- Unsolved case to solved case
- Date rape cases



How does it work?

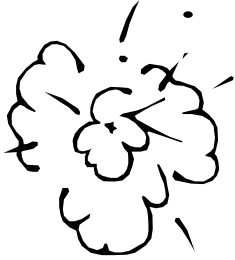
- DNA profile is developed from sample collected from a convicted offender
- Profile is placed in the OFFENDER database

Search is performed to see if any unknown samples with in the database match

Offender database

Contains DNA profiles taken from persons convicted of specific criminal offenses

Match between casework and offender

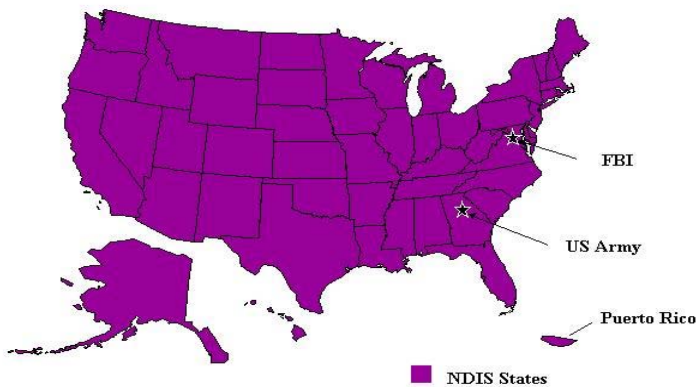


- Clear a case by developing a suspect



NDIS Participants

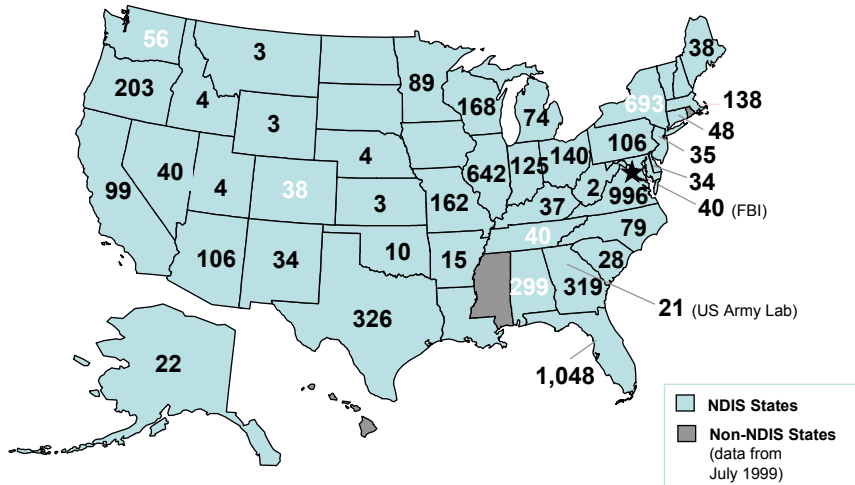
September 2004 - 50 States, US Army, the FBI, and Puerto Rico



Investigations Aided

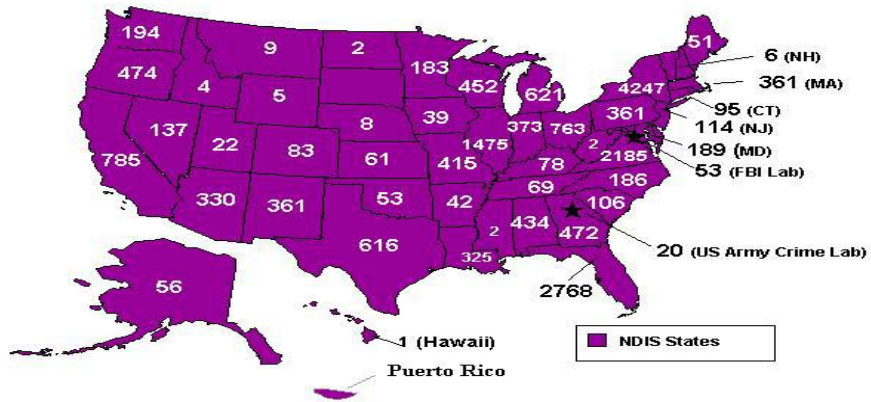
December 2002

Total = 6454 in 42 States



Investigations Aided:

20,338 in 47 States and 2 Federal Laboratories and Puerto Rico through September, 2004



Myth vs. Reality

CSI:

State of the art equip
Unrealistic turn around
times
Unlimited staff
All crimes solved in 42
mins



CSI Effect

Pro:

Increased public
awareness and
interest in forensic
science

Con:

Unrealistic juror
expectations of what
forensic science can
do



THANK YOU!!

Any questions?

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the Law

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