The Real CSI: Using DNA to Identify Criminals and Missing Persons

San Jose State University          May 2, 2012
Overview

- Forensic DNA in the media – perceptions and reality
- The power and limitations of nuclear (STR) DNA testing
- Offender DNA Databasing
- Missing/Unidentified Persons
  - Kinship
  - Mitochondrial DNA
- Familial DNA Searching
- Ethical Issues
DNA in the News: Gun Possession Proven

Lil Wayne pleads guilty to gun possession, faces one-year prison sentence

October 22, 2009 - music-mix.ew.com
DNA in the News: the Innocent Released

October 26, 2009 - www.cbsnews.com

Dean Cage, An Innocent Man

NEW YORK (CBS/AP) Dean Cage once said "If you believe in something, fight for it." Those hard-earned words rang out hours after the 41-year-old was released from prison more than a year ago after serving more than 12 years for a rape he didn't commit.

He was convicted in 1996 and sentenced to 40 years in prison for the rape of a 15-year-old girl, who, at the time, identified him as her attacker. But Cage always maintained his innocence and asked for DNA tests to prove it. He said his family had even tried to pay for it themselves.
DNA in the News: From Strange Sources

Blood from leech nabs robber

NICK CLARK
October 20, 2009 07:08am

TASMANIA Police have used blood taken from a leech to match DNA eight years after an aggravated robbery.

In what is believed to have been a world first, police found the engorged leech about an hour after the crime.

Peter Alec Cannon, 54, of Lalla Rd, Karcola, north of Launceston, pleaded guilty in court yesterday to an aggravated armed robbery committed on September 20, 2001.

Detective Inspector Nick Johnston said he had never heard of a leech being involved in a crime scene before.

"It is the oddest way of conveting anyone I have ever been involved in," the 25-year police veteran said.

"I have not been able to find any similar cases anywhere in the world -- nothing like this at all."

Det-Inspr Johnston said the leech was the only thing found during a full forensic investigation.

"It was the only evidence we found, and as there was no evidence of any leech bites from the victim or the police present we thought it was a good chance to have come from one of the offenders," he said.
CSI Bolton: Boy detective foils serial burglar after collecting DNA evidence from drink can

By JAMES TOZER
Last updated at 4:51 PM on 27th October 2009

As a fan of crime-solving TV series CSI, schoolboy Leon Yates knew exactly what to do when his neighbour was burgled.

Although the terraced streets of his home town of Bolton are a long way from sun-drenched Florida, the 12-year-old proved he had been paying attention.

He had seen the suspect swigging lemonade before the break-in, and when he saw the empty can lying in the street outside he swept it into a plastic bag without touching it and handed it to police.

The budding detective’s brainwave was rewarded after DNA tests unmasked the intruder as a serial burglar and he was sent to prison.
DNA in the News: Controversy

DNA Profiling: You May Be Next

Since its discovery a quarter century ago, the DNA fingerprint has been hailed as a pivotal tool in solving crimes and exonerating those wrongly convicted.

But as it celebrates its 25th anniversary, the question of how DNA evidence is being used and how samples are being extracted, have come under fire from civil rights activists and many criminal justice experts.

Proposition 69, passed in 2004, made California one of now 21 states that require DNA sampling for some arrestees. This voter-approved initiative mandated that this extend to all felony arrestees by Jan. 1, 2009 -- and the legal backlash has already begun.

Earlier this month the American Civil Liberties Union of Northern California (ACLU-NC) filed a lawsuit against the state of California charging that the statute on DNA collection violates search and seizure laws under the Fourth Amendment, and due process under the 14th Amendment.

October 22, 2009 - www.sfgate.com
What is a Forensic Scientist?
Typical day in the lab...

Progress Is Minimal in Clearing DNA Cases

Stacy Vanderschaed, at the Hetzberg-Davis Forensic Science Center in Los Angeles, where the Police Department has some 2,100 cases awaiting DNA analysis.

By SOLOMON MOSHE
Published: October 24, 2008

LOS ANGELES – Local and state law enforcement agencies have made uneven progress in reducing a nationwide backlog of cases awaiting DNA analysis over the past four years, according to reports filed by more than 100 agencies with the National Institute of Justice.
Pre-PCR
POST PCR
POST PCR
Forensic DNA
DNA in the Cell

- Cell nucleus
- Chromosome
- Double-stranded DNA molecule
- Target Region for PCR
- Individual nucleotides
DNA Amplification with the Polymerase Chain Reaction (PCR)

1. **Starting DNA Template**
2. **Separate strands**
   - (denature)
3. **Add primers**
   - (extend primers)
4. **Make copies**
   - (anneal)

*Forward primer*

*Reverse primer*
In 32 cycles at 100% efficiency, 1.07 billion copies of targeted DNA region are created.
Short Tandem Repeats (STRs)

The repeat region is variable between samples while the flanking regions where PCR primers bind are constant.

Homozygote = both alleles are the same length

Heterozygote = alleles differ and can be resolved from one another
Multiplex PCR

- Up to 16 Markers Can Be Copied at Once
- Sensitivities to levels less than 1 ng of DNA
- Ability to Handle Mixtures and Degraded Samples
- Different Fluorescent Dyes Used to Distinguish STR Alleles with Overlapping Size Ranges
310/377/3100 Electrophoresis
A Sample STR DNA Profile:
The “Power” of STR typing

- Statistical frequency
- Amplification from as little as a few cells
- Large databases for comparison
How “rare” is a DNA profile?

- 15 STR markers (loci) in one amplification reaction
- Each locus is INDEPENDENT of all others
- Therefore, the overall frequency for a 15-locus profile is the product of the frequencies of each individual locus
- 15 dice – what is the chance of rolling 15 sixes?
- $2.1 \times 10^{-12}$ or 1 in $4.7 \times 10^{11}$
A Sample STR DNA Report:

• STRs (autosomal) have a high power of discrimination. This profile is estimated to occur at random, among unrelated individuals, in approximately 1 in 9.3 quintillion (Caucasian) people.
Types of DNA

**Nuclear**
- 2 copies/cell
- Inherited from both parents
- Unique to individual

**Mitochondrial**
- >1000 copies/cell
- Maternally inherited
- Not unique to individual
Human Mitochondrial DNA

Features of Mitochondrial DNA

- Circular genome
- 1000's of copies per cell
- Maternally inherited
- Small genome: ~16,500 bp
- ~10% non-coding region
- Maternally related individuals share mtDNA type

Useful for analysis of samples not amenable to nuclear analysis

Cassandra Calloway
Organization of mtDNA

HV1
(hypervariable region 1)

HV2
(hypervariable region 2)

Control region

mtDNA
16,569 base pairs
Advantages of mtDNA

- High copy number
  limited sample
  hair, teeth, bones
- Less prone to degradation
  structure, location
- Highly variable between individuals
- Maternal inheritance
  maternal relatives source of known
  sample in missing persons cases
Steps in mtDNA analysis

1. **Extraction**
   - removal of DNA from sample
Steps in mtDNA analysis

2. **Amplification** (Polymerase Chain Reaction)
   - make many copies of specific regions of DNA

   ![Diagram showing multiple sets of copies](image-url)
Steps in mtDNA analysis

3. **Sequencing**
   - determine order of bases

4. **Sequence Comparison**

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<th>Case #2</th>
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<td>GC\textcolor{red}{CATATT}GCG\textcolor{red}{GCCTA}</td>
</tr>
</tbody>
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EXCLUSION       CANNOT EXCLUDE
Historic Identifications

- Tsar Nicholas II (FSS, AFDIL, RAS)
- Anna Anderson Manahan - not Anastasia
- Jesse James (Melton/Stoneking)
- Vietnam Unknown Soldier (AFDIL)
Limits of DNA Testing

- DNA identifies donor - not necessarily the perpetrator
- DNA does not tell us when evidence was deposited at crime scene--only that it is there
- DNA does not tell us how evidence got there
- DNA does not tell us who else might have been present when DNA was deposited at scene
DNA from Twin - RS
DNA from Twin - TS
BFS DNA Lab Programs

• Criminal Casework
• Convicted Felon DNA Data Bank
• COLD HIT Program
• Method Development and Training
• Post Conviction Testing
• Missing Persons DNA Program
• Mass Disasters
• Human Rights Violations
Convicted Offender DNA Data Bank

- Proposition 69 has greatly expanded pool of offenders
- At ~1,900,000 qualifying profiles – CA largest State Database
- Nationally, “CODIS” has >10 million offender profiles, >400,000 crime scene profiles
- Familial searching
CODIS:

- Combined DNA Index System
- Local, State and National databases tied together
- Various indices: convicted offender, forensic unknown, unidentified remains, family references...
Levels of CODIS

NDIS (180)

SDIS

LDIS 22 in CA, i.e. :

Oakland PD

Fresno DOJ

LASD
Proposition 69

- Passed by the California voters in the November 2004 election, effective 11/3/04
- Changed the primary DNA collection method to buccal samples
- Prior to Prop 69, the Databank had received a total of 343,000 samples since its inception in 1989.
- Over 1.5 million buccal samples collected since Proposition 69 passed.
The life of a sample at the DOJ Databank
Kit Breakdown
Kit Breakdown cont.
Kit Breakdown cont.