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Emerging Issues in Forensic DNA Profiling: Databases and Advisory Boards

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Emerging issues in forensic DNA profiling: Databases and advisory boards

Dan E. Krane, Wright State University, Dayton, OH
Professor of Biological Sciences; CEO of Forensic Bioinformatics, Inc.

National Conference of State Legislatures
Legal Services Staff Section
Professional Development Seminar / DNA Evidence Panel
Columbus, Ohio
September 11, 2008
Quantities of DNA

- Our bodies are made of trillions of cells
- Optimum amount for DNA profiling: 0.5 to 2.0 ng (a nanogram is one billionth of a gram)
- 6 to 7 pg of DNA in each diploid human cell (a picogram is one trillionth of a gram)
- A typical fingerprint contains hundreds of cells
Possible DNA sources

- Combs
- Knives
- Toothbrushes
- Dental floss
STRs

• **Short tandem repeat**
• Describes a type of DNA polymorphism in which:
  – a DNA sequence repeats
  – over and over again
  – and has a short (usually 4 base pair) repeat unit
• A length polymorphism -- alleles differ in their length

3 repeats: **AATG AATG AATG**
4 repeats: **AATG AATG AATG AATG**
5 repeats: **AATG AATG AATG AATG AATG**
6 repeats: **AATG AATG AATG AATG AATG AATG AATG**
Statistical estimates: the product rule

### Allele Frequencies

<table>
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<tr>
<th>Locus</th>
<th>Race</th>
<th>(N = 203)</th>
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<tr>
<td>D3S1358</td>
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<tr>
<td>Allele</td>
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</table>

0.222 \times 0.222 \times 2 = 0.1
### Statistical estimates: the product rule

#### Allele Frequencies

**Locus D3S1358**
- **Race**: Caucasian
- **N**: 203

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**Locus vWA**
- **Race**: Caucasian
- **N**: 196

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1 in 10 × 1 in 111 × 1 in 20 = 0.1

1 in 116 × 1 in 17 × 1 in 16 = 1 in 31,552

1 in 22,200

1 in 113,400

1 in 79,531,528,960,000,000,000

1 in 80 quadrillion
Two relatively new DNA tests

- Mitochondrial DNA (mtDNA) sequence
  - Sensitive but not discriminating

- Y-STRs
  - Useful with mixtures
  - Paternally inherited
The CODIS database

- **CODIS**: Combined DNA Index System
- Formalized by the DNA Identification Act of 1994
  - Maintained by the FBI
  - More than 170 law enforcement agencies participate
  - Used to generate investigative leads
- Produced more than 71,500 “cold hits” as of June, 2008
- Contains over 6,031,000 DNA profiles
The CODIS database

• DNA Fingerprint Act of 2005
  – Dramatic expansion of suitable profiles
  – If it is acceptable to a state, it is acceptable for CODIS

• Who should be included in state databases?
  – Felons
  – Arrestees?
  – Everyone?

• How do you get out once you are in a database?
Database expansion

• Advantages
  – Obvious societal benefit
  – Removal of existing disparities in database composition
  – Individuals only accrue benefit when databases are very large

• Disadvantages
  – False leads due to innocent contact
  – A new kind of frame-up
Familial searches

- Database search yields a close but imperfect DNA match
- Can suggest a relative is the true perpetrator
- Great Britain performs them routinely
- Reluctance to perform them in US since 1992
- NRC report
- Can they be done? Should they be done?
Relatedness does make a difference

- Randomized Individuals
- Simulated Cousins
- Simulated Siblings

Number of pairwise shared alleles vs. Percent of total (%)
Is the true DNA match a sibling or a random individual?

• Given a closely matching profile, who is more likely to match, a sibling or a randomly chosen, unrelated individual?

• Use a likelihood ratio

\[ LR = \frac{P(E \mid \text{relative})}{P(E \mid \text{random})} \]
Probabilities of siblings matching at 0, 1 or 2 alleles

- Numbers can be generated but guidance is needed on:
  - Tolerance for false positives
  - The size of the pool of alternative suspects

\[
P(E \mid \text{sib}) = \begin{cases} 
\frac{P_a \cdot P_b \cdot HF}{4}, & \text{if shared} = 0 \\
\frac{P_b + P_a \cdot P_b \cdot HF}{4}, & \text{if shared} = 1 \\
\frac{1 + P_a + P_b + P_a \cdot P_b \cdot HF}{4}, & \text{if shared} = 2 
\end{cases}
\]

HF = 1 for homozygous loci and 2 for heterozygous loci
Laboratory advisory boards and committees

- Virginia’s Scientific Advisory Committee
  - Statute requires approval of all protocols and procedures
  - What level of review is appropriate?

- Virginia’s Forensic Science Board
  - Responsible for policy decisions
  - Can request investigations/analyses

- Overall cost: approximately $100,000 per year
Laboratory advisory boards and committees

• Independent voice to ensure proper staffing, resources and quality
• Efficient venue for improving protocols and procedures
• Tangible deliverables to date:
  - Gun shot residue reporting, mtDNA testing, breath alcohol instrumentation, analytical equipment platforms, familial searches, Y-STR testing, minimizing examiner bias in protocols
Potential problems with existing internal reviews

• Bias
  – Internal reviewers may favor superficial solutions because they identify with the organization and believe in it

• Blame
  – Internal reviewers may therefore overlook root causes and find someone to blame
Are advisory boards and commissions cost effective?

- Costs of incarceration for one false felony conviction exceeds $105,000.

- State legislated restitution for five years (an average felony sentence) in prison:
  - Ohio: $201,650
  - Texas: $250,000
  - Wisconsin: $125,000
  - Tennessee: $1,000,000
  - Missouri: $91,312
Are advisory boards and commissions cost effective?

- Median annual budget for publicly funded crime labs in 2005 was $1.7 million.

- *Post hoc* investigation can be costly.
  - Houston: cost of Bromwich report *alone* was $5.1 million.

- What is the cost of the public’s loss of confidence in local law enforcement?

- $100,000 of prevention is worth millions of cure.
For more information:

- Internet
  - **Forensic Bioinformatics Website:** [http://www.bioforensics.com/](http://www.bioforensics.com/)

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- Dan.Krane@wright.edu