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Gang rape cases and use of likelihood ratio statistic

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Gang Rape

- **Definition**
  - ✓ We talk about rape when the victim is **forced** to have **sexual relation**.
  - ✓ Gang rape occurs when a **group** of people participate in the rape of a **single victim.**

- **Effects and aftermath of rape are multiples**

Physical effects

- ✓ Bodily pain
- ✓ Sexually transmitted diseases (STDs), …

Psychological effects

- ✓ Feelings of severe anxiety and stress
- ✓ Depression
- ✓ Sleep disorders
- ✓ Dissociative identity disorder, …

Gang Rape

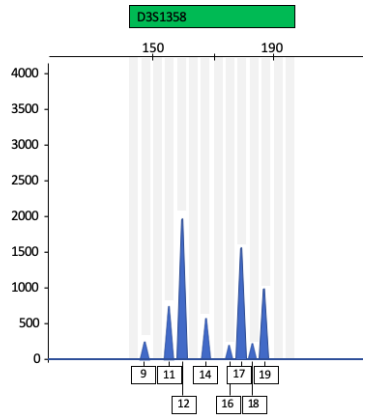
- **Gang Rape Consequences**
  - ✓ The aftermath of rapes involves a cluster of physical and psychological effects and the victims in shock are **unable** to identify their attackers
  - ✓ The Gang Rapes can result in the **Death** of the victims

One only alternative to identify the contributors

DNA Analysis

DNA Analysis

- The Forensic labs use **DNA fingerprints** since the 1990's **to identify** suspects whose DNA may match evidence at crime scenes
- DNA profiling can be **so powerful** and has been used **successfully** in so many cases that some people think it is nearly infallible.
- But the reliability of DNA profiling **varies**, it is **most reliable** when the evidence contains **plenty of DNA** from just one or two people.
- During the investigation of sexual abuse, it is not rare that mixed genetic material from two or more persons is detected.



Major problem in gang rape cases is the **complex DNA mixture**

Importance of the Sampling

- the objectif of this presentation is to provide a snapshot of protocol to avoid the complex DNA mixture

- Example of gang rape case with several contributors

EVIDENCE:

Bath Towel found on crime scene

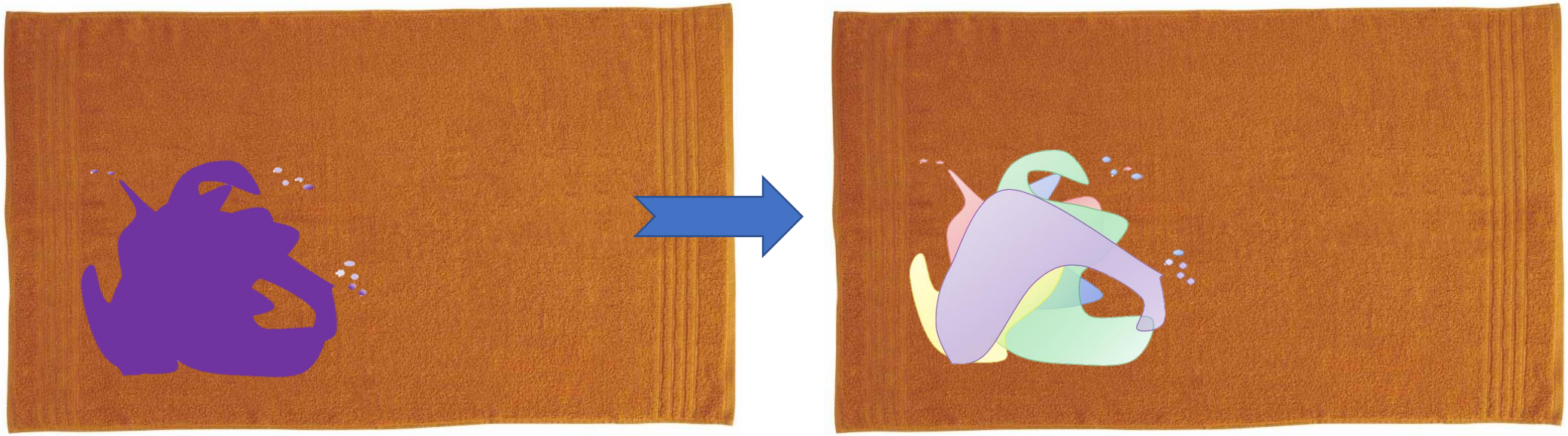
Importance of the Sampling

Step 1: Preliminary research => Detection of semen

- Using of the **acid phosphatase test,** This test is designed as a preliminary screening test to aid in the identification of semen stains
- The **acid phosphatase enzyme** has the ability to cleave a phosphate group from alpha-napthyl phosphate to form napthol, which when coupled with **Brentamine Fast Blue B** forms a **purple** azo dye.

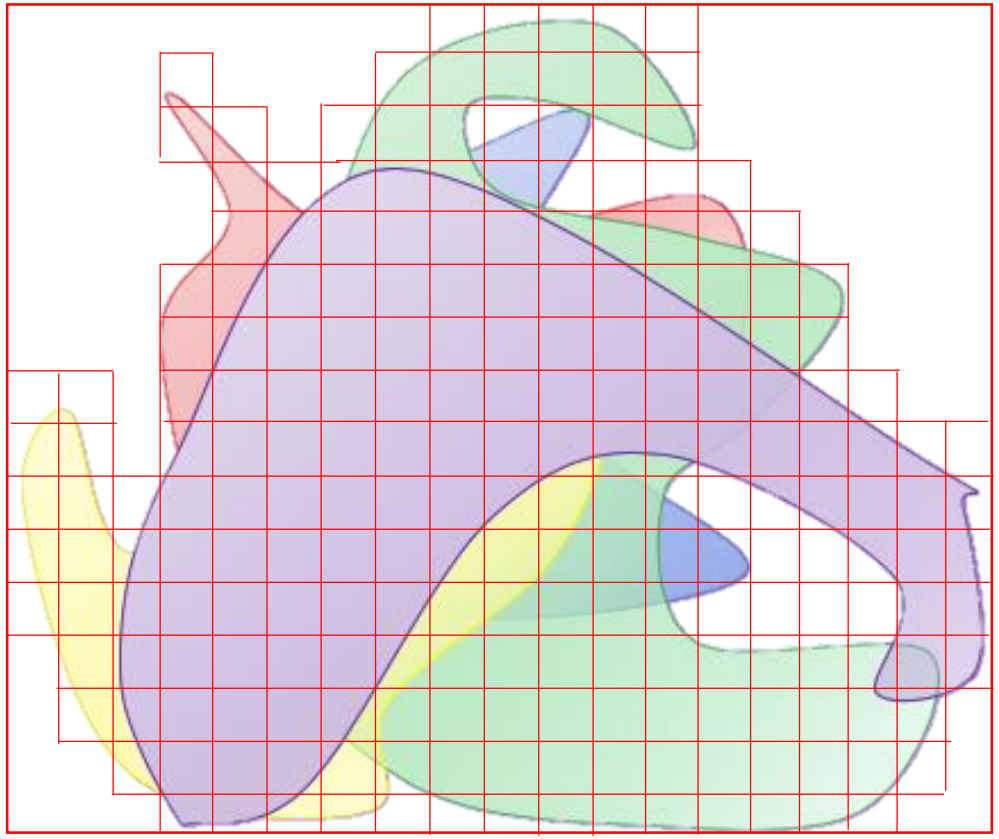
Importance of the Sampling

- **Acid phosphatase test** is a presumptive test and the present of semen must be confirmed by microscopic examination for spermatozoa.
- But the screening test can’t allow to discern the number of contributors and the location on the stains



Importance of the Sampling

- A solution => the sampling using a **square grid technique** in blind.



Contributor	Unique DNA Profil	Mixture					
A	54	A+B	8	C+E	1	A+B+C+E	18
B	6	A+C	2	A+D+E	7	A+B+D+E	16
C	6	A+E	6	A+B+E	4	A+B+C+D+E	12
D	11	A+D	2	B+C+E	5		
E	17	D+E	15	A+C+E	3		

Results	193
Unique DNA Profil	94
Mixture with 2 contributors	34
Mixture with 3 contributors	19
Mixture with 4 or 5 contributors	46

Importance of the Sampling

CONCLUSION

- In the laboratory this protocol allowed to identify the contributors and resolve a lot of cases:
    - Gang rape
    - Gang robbery
    - Narcotic offence
    - Murder cases
    - Cold cases

Likelihood Ratio

Accordance with the recommendations of the DNA commission of the international society of forensic genetics

- Likelihood ratio is the preferred approach to mixture interpretation

(DNA commission 2005)

- Probabilistic approaches and likelihood ratio principles are superior to classical methods

(DNA commission 2012)

The **LR's** good legal and scientific standing underlies **forensic** science's credibility in court.

Likelihood Ratio

In Forensic, the likelihood ratio (LR) is alternative pair of hypotheses:

- Prosecutor's hypothesis (**Hp**): DNA came from the suspect
- Defense hypothesis (**Hd**): DNA came from an unknown person

Bayesian Framework and Likelihood ratio

$$\mathbf{LR} = \frac{\Pr(\text{data}|\text{Hprosecution})}{\Pr(\text{data}|\text{Hdefence})}$$

Data: alleles and their peaks
Ratio of two probability

Likelihood Ratio

- Genotyping of biological trace from scenes of crimes is often complicated:
    - Amount of DNA may be limited
    - Quality of the DNA may be compromised

- There are two key phenomena to consider:
    - Allele or locus “**Drop out**”: is defined a signal that is below the limit of the detection threshold
    - Allele or locus “**Drop in**”: is an allele that is additional to the assumed contributor

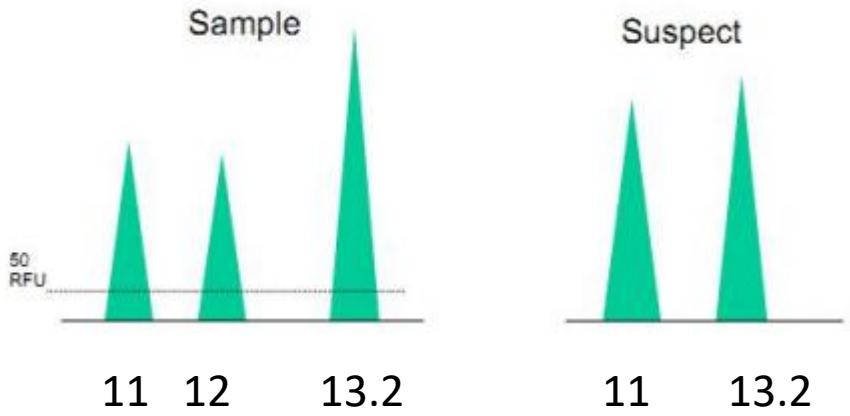
Likelihood Ratio

- Low vs High template DNA

High	Low
The chromatogram reflects the composition of the sample • No drop-out • No drop-in	The chromatogram does not reflect the composition of the sample • Allele drop-out • Allele drop-in • Stutter, …

Likelihood Ratio

- Example: High template DNA and two person mixture



	Locus A
Evidence	11 12 13.2
Suspect	11 13.2
Victim	12 13.2

Hp (Prosecutor's hypothesis)	Victim + Suspect contributed to the sample
Hd (Defense hypothesis)	Victim + unknown person (unrelated to the suspect) contributed to the sample

Likelihood Ratio

- Mixture of two persons under **Hp**

	Locus A
Evidence	11 12 13.2
Suspect	11 13.2
Victim	12 13.2

Hp (Prosecutor's hypothesis)	Victim + Suspect contributed to the sample

Pr(Evidence|Hp) = 1

Likelihood Ratio

- Mixture of two persons under **Hd**

	Locus A
Evidence	11 12 13.2
Unknwon	11 11 11 12 11 13.2
Victim	12 13.2

Hd (Defense hypothesis)	Victim + unknown person (unrelated to the suspect) contributed to the sample

$$\mathbf{Pr(evidence|Hd) = 2p_{11}p_{12} + 2p_{11}p_{13.2} + p_{11}^{\,2}}$$

$$LR = \frac{1}{\mathbf{2p_{11}p_{12} + 2p_{11}p_{13.2} + p_{11}^{\,2}}}$$

Likelihood Ratio

- Mixture of two persons under **Hd**

Unknown 1	Unknown 2
11 11	12 13.2
12 12	11 13.2
13.2 13.2	11 12
11 12	13.2 13.2
11 12	11 13.2
11 12	12 13.2
11 13.2	12 12
12 13.2	12 13.2
…	….

Hd (Defense hypothesis)	2 unknown individuals (unrelated to the suspect) contributed to the sample

Pr(evidence|Hd) = $2(p_{11}^2 p_{12} p_{13.2} + p_{12}^2 p_{11} p_{13.2} + p_{13.2}^2 p_{11} p_{12} + 2p_{11} p_{12}^2 p_{11} p_{13.2} + 2p_{11} p_{12}^2 p_{12} p_{13.2} + 2p_{11} p_{13.2}^2 p_{12} p_{13.2})$

$$LR = \frac{1}{2(p_{11}^2 p_{12} p_{13.2} + p_{12}^2 p_{11} p_{13.2} + p_{13.2}^2 p_{11} p_{12} + 2p_{11} p_{12}^2 p_{11} p_{13.2} + 2p_{11} p_{12}^2 p_{12} p_{13.2} + 2p_{11} p_{13.2}^2 p_{12} p_{13.2})}$$

- Increasing the number of unknowns increases the number of terms under Hd

Conclusion

- In complicated crime scene cases
  - The sampling protocol is very important => focus on enforcing the **square grid technique**
  - Use probabilistic approaches and likelihood ratio in your DNA results as:
    - DNA mixture
    - Partial DNA profile

http://www.lrmixstudio.org (free software)

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Thanks for your attention