DNA Mixture Interpretation Principles: Observations from a NIST Scientific Foundation Review
AAFS 2019 Workshop #10 (February 18, 2019; Baltimore, MD)

Strategies for Implementing Evaluative Reporting and Testimony

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Briefing Overview

- Background
- Case Assessment and Interpretation (CAI) model
- Progression steps for implementation
- Bayes theorem
- Example
- Summary

Background

- Evaluative reporting for us came out of necessity
- The question that often matters most in our cases is not **whose** DNA is on the evidence but **how** did it get there?
- Can we scientifically address DNA transfer and persistence questions?
- If so, how?

Challenges

- Transposing the conditional
- Mixing up the LRs – distinguishing the sub-source from activity
- Evaluating findings led propositions
- Mixed reviews for DNA transfer rates and mechanisms in the published literature

This type of evaluation comes with lots of uncertainty

Solution

- The LR framework can account for uncertainty

$$LR = \frac{\Pr(E \mid H_1, I)}{\Pr(E \mid H_2, I)}$$

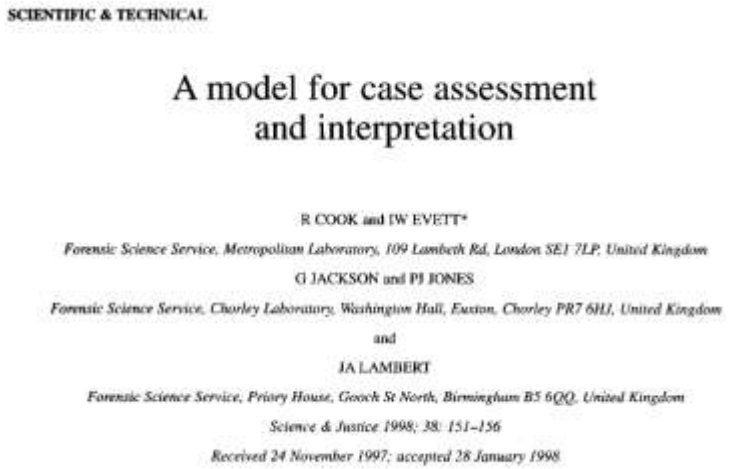
- It is based on three scientific principles of interpretation

Scientific Principles of Interpretation

$$LR = \frac{\Pr(E \mid H_1, I)}{\Pr(E \mid H_2, I)}$$

1. To consider the uncertainty of any given hypothesis it is necessary to consider at least one alternative hypothesis or proposition.
2. Scientific interpretation is based on evaluating the probability of the evidence given the proposition.
3. Scientific interpretation is conditioned by the framework of circumstances within which the competing hypotheses are to be evaluated (i.e., the non-scientific evidence).

References



SCIENTIFIC & TECHNICAL

A model for case assessment and interpretation

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Science & Justice 1998; 38: 151–156
Received 24 November 1997; accepted 28 January 1998

SCIENTIFIC & TECHNICAL

A hierarchy of propositions: deciding which level to address in casework

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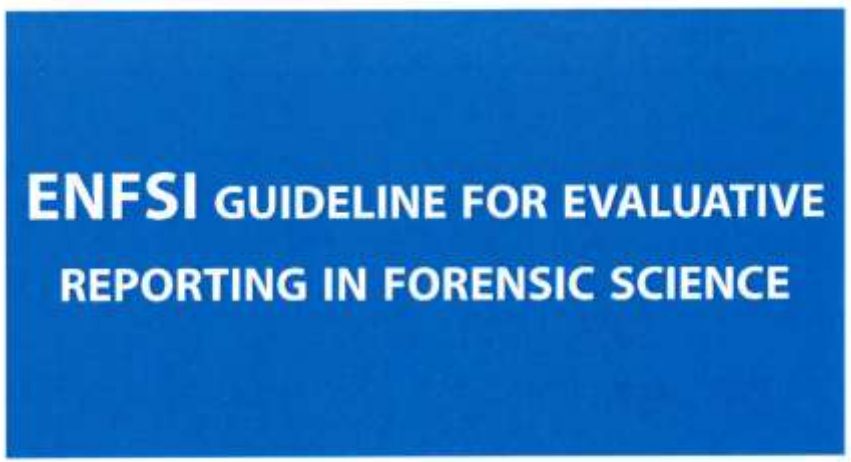
Science & Justice 1998; 38: 231–239
Received 2 April 1998; accepted 19 June 1998



ENFSI GUIDELINE FOR EVALUATIVE REPORTING IN FORENSIC SCIENCE

Strengthening the Evaluation of Forensic Results across Europe (STEOFRAE)

European Network of Forensic Science Institutes

ENFSI

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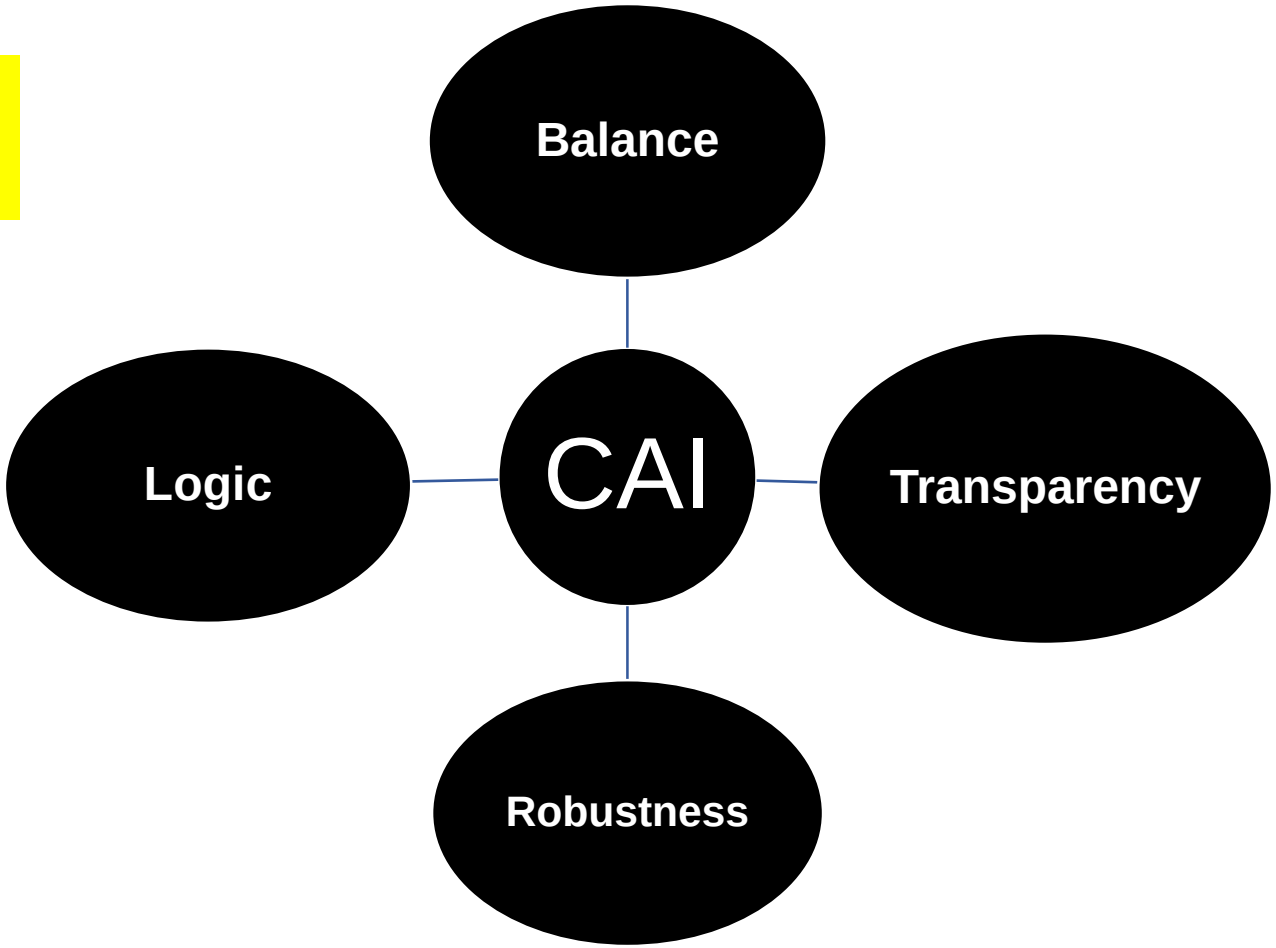
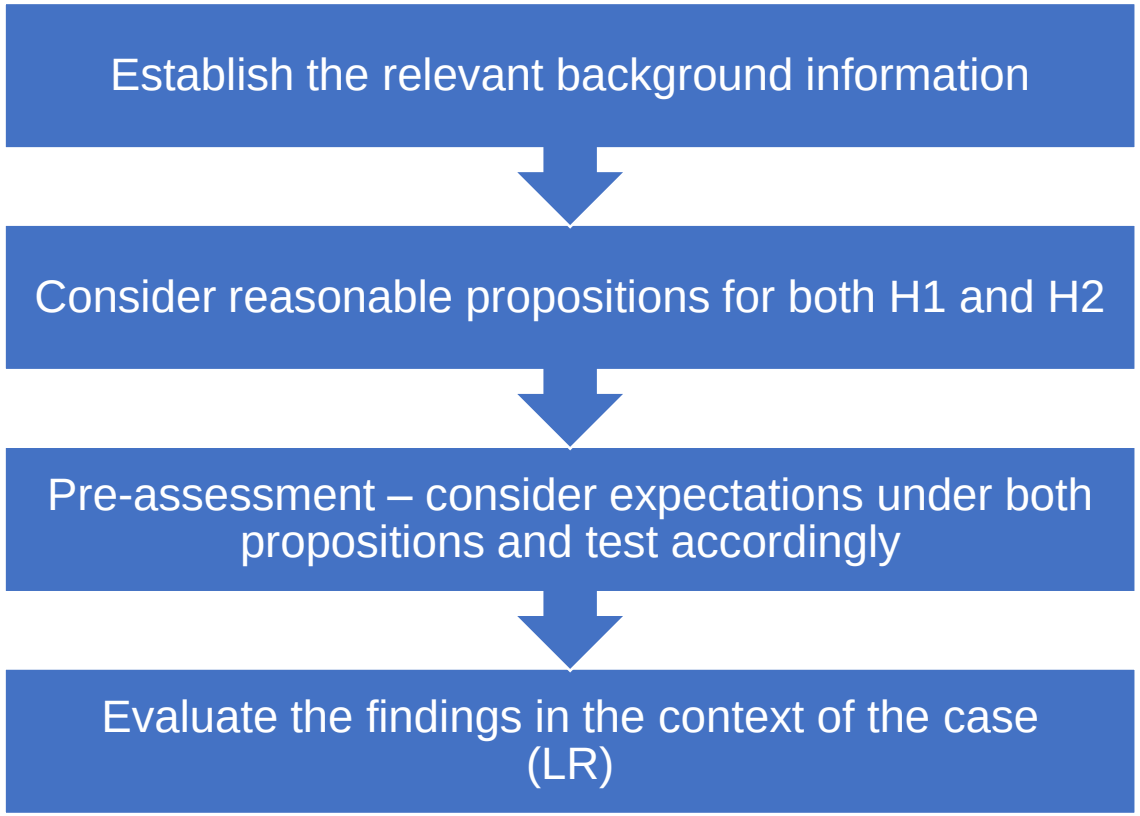
CAI Framework

Information
Propositions
Expectations



The CAI Process



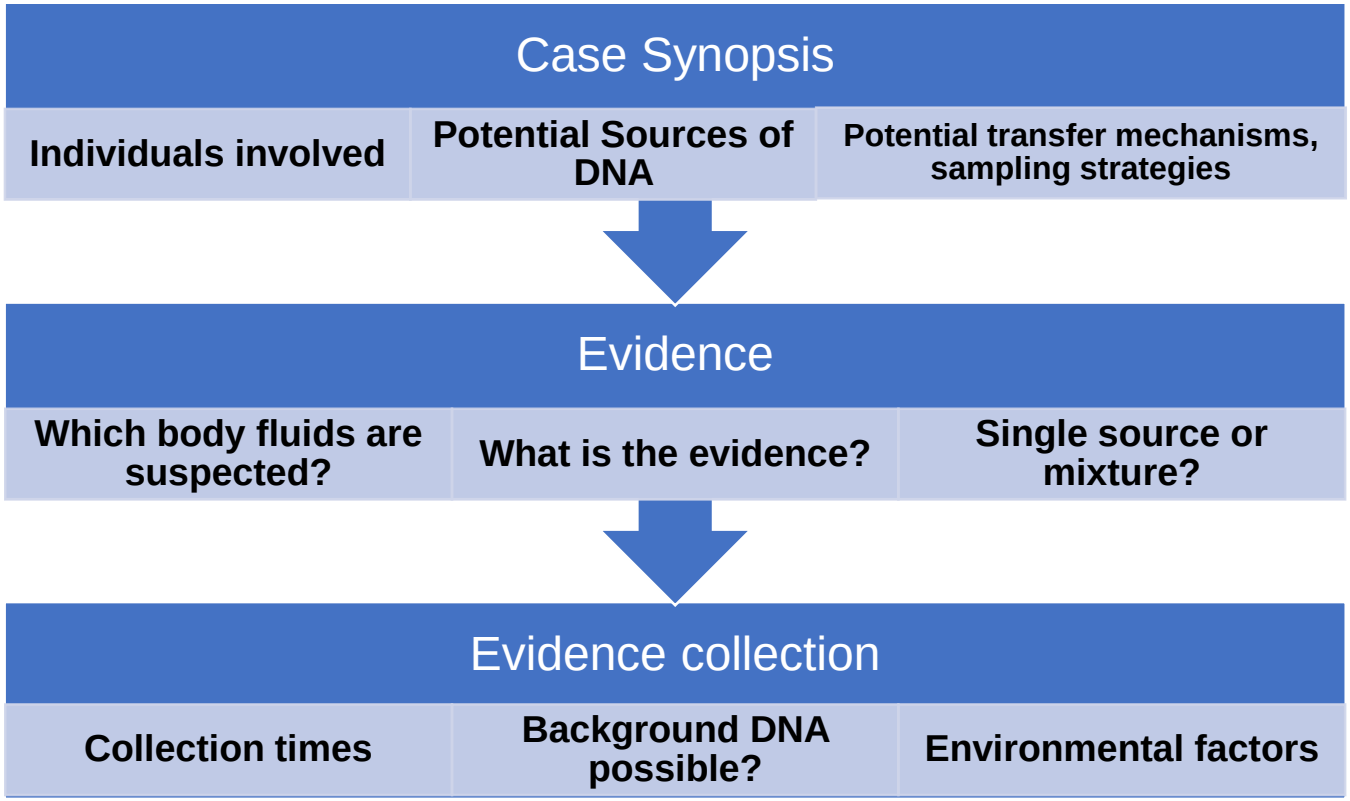
Golf Ball Example

- The evidence is that we have observed a golf ball in a hole.
- If we only consider explanations, it could have gotten there many different ways, including from “a hole in one” or “par for the hole”.
- But what if we have conditioning information (I) that the green for this hole is 600 yards, considered a “par 4” by the golf experts, and there is no record of “a hole in one”?
- Then we should instead evaluate the probability of the evidence given two competing propositions in light of this conditioning information,
  - H1: Mr. X hit the ball in the hole for par
  - H2: Mr. X hit a hole in 1.

Case Pre-assessment

- Seeks to specify potential findings prior to performing any analyses or prior to knowing the results, in order to:
  - Assess the potential value
  - Assess the probability with which these results may be obtained under each of the competing propositions
- These results are what I would expect to find…
- These expectations may be documented prior to your actual examinations, assigning some relative probability (between 0 and 1)

Expectations for DNA results

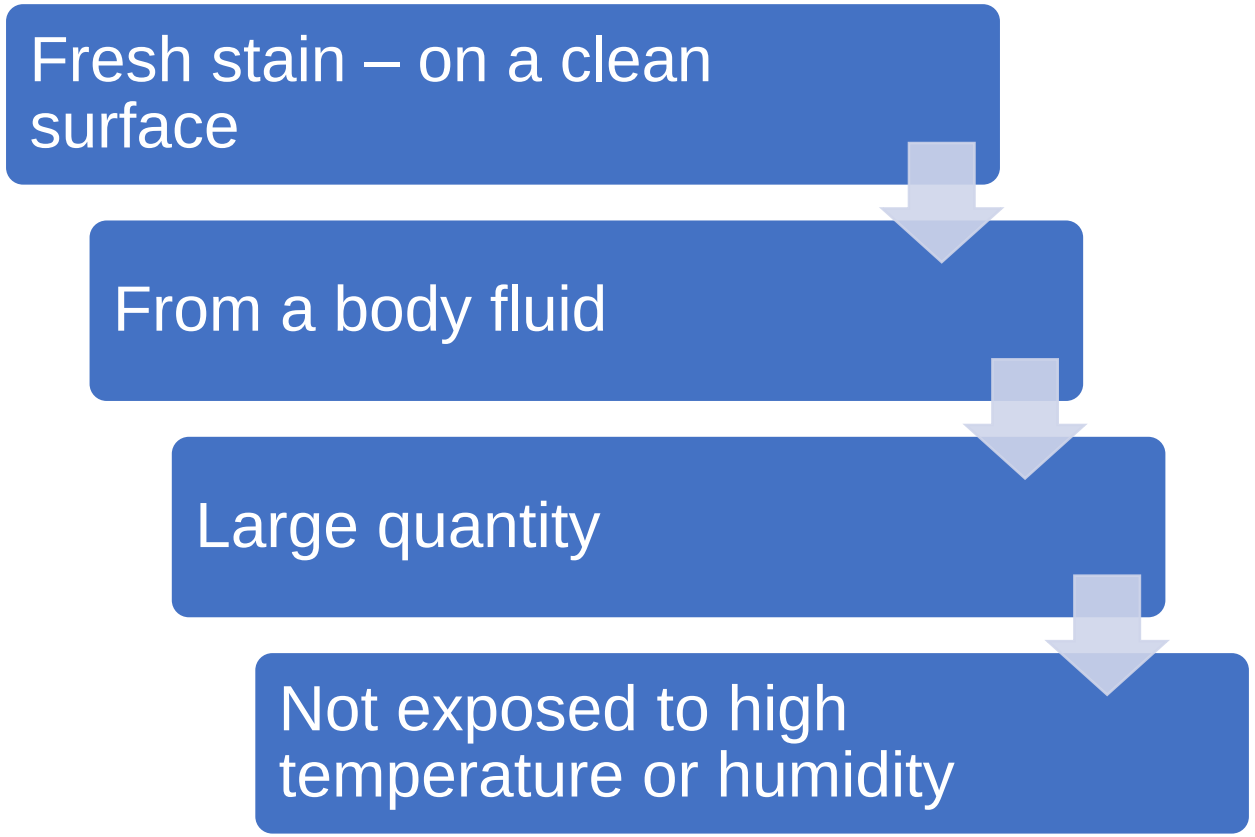


These pre-assessment considerations will help to inform expectations for results, determine evidence testing strategies, and formulate reasonable activity level propositions.

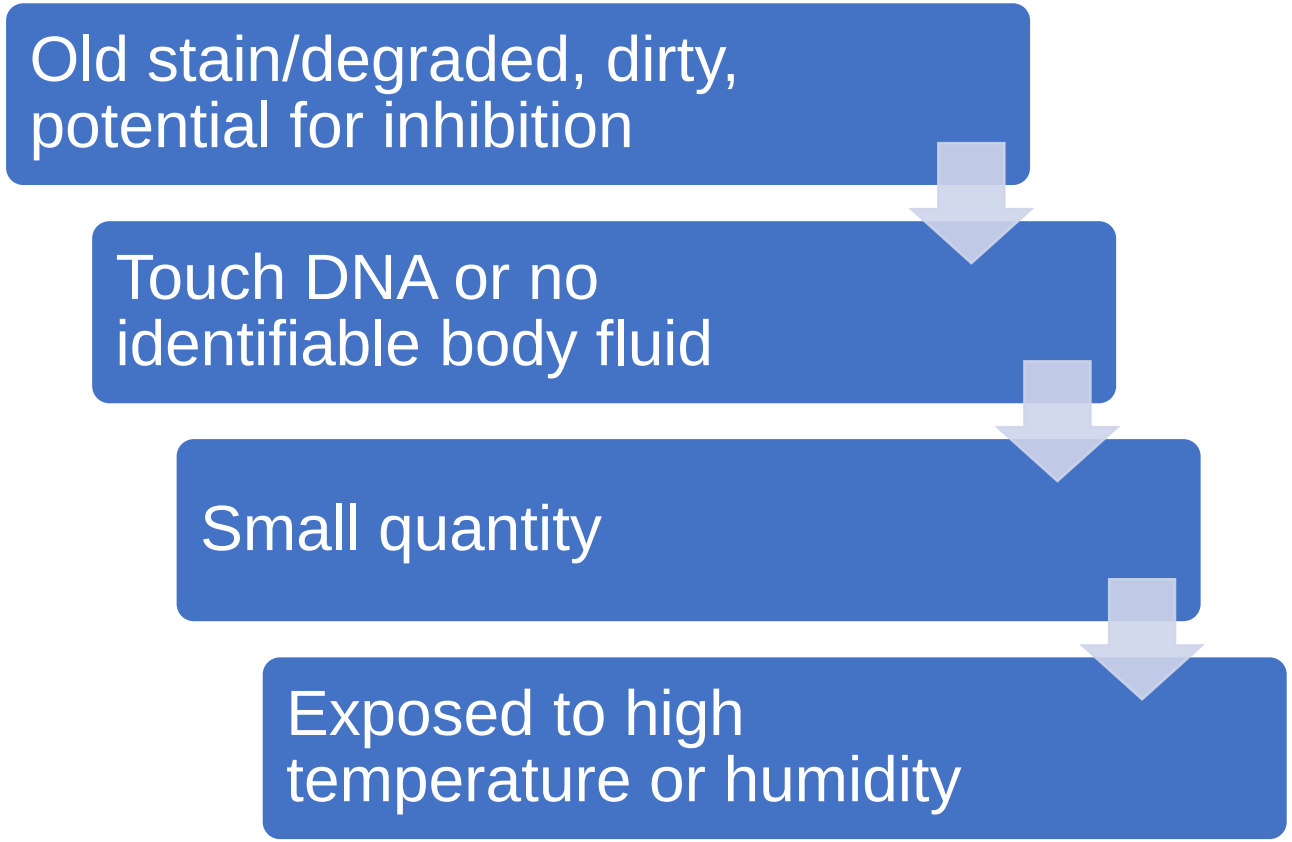
Other pre-assessment strategies

- Background DNA - consider testing other evidence based on H2 proposition
- Be implicit with DNA transfer assessments
- Consider the implications with unexpected results

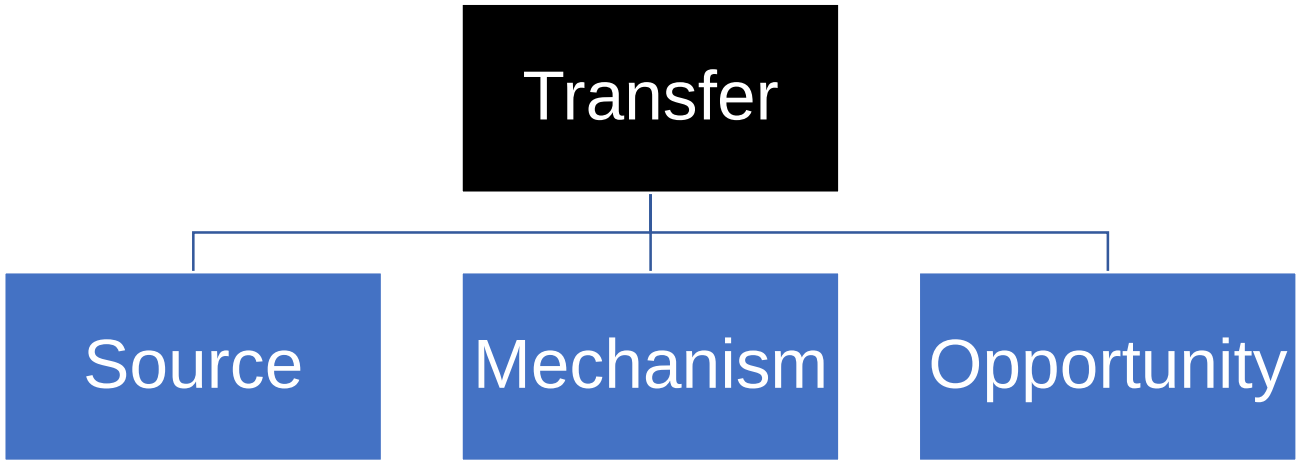
Expectations for a good quality/high template sample



Expectations for a poor quality/low template sample



Pre-assessment - DNA transfer mechanisms



Pre-assessment – DNA transfer mechanisms

- Source – you need a source of where the DNA would have originated
- Mechanism – in light of the case circumstances, this usually involves the different steps (primary/secondary) and vector(s) required for transfer
- Opportunity – close proximity and time to make the transfer

Factors affecting transfer mechanisms

General Expectations	More Transfer	Less Transfer
State of the body fluid	**WET**	**DRY**
Type of substrate	**HARD**	**SOFT**
Type of contact	**FRICTION/FORCE**	**PASSIVE**
Length of contact	**PROLONGED**	**SHORT**
Shedder status	**GOOD**	**POOR**

Progression Steps

- Training our Analysts
- Create a Library of published literature
- Supplement with internal validation
- Awareness training to our customers
- Case pre-assessment form
- Incorporate activity level propositions where needed in our reports

Bayes' Theorem

- Odds form:

Posterior Odds **LR** **Prior Odds**

$$\frac{Pr(H_1|E)}{Pr(H_2|E)} = \frac{Pr(E|H_1)}{Pr(E|H_2)} \times \frac{Pr(H_1)}{Pr(H_2)}$$

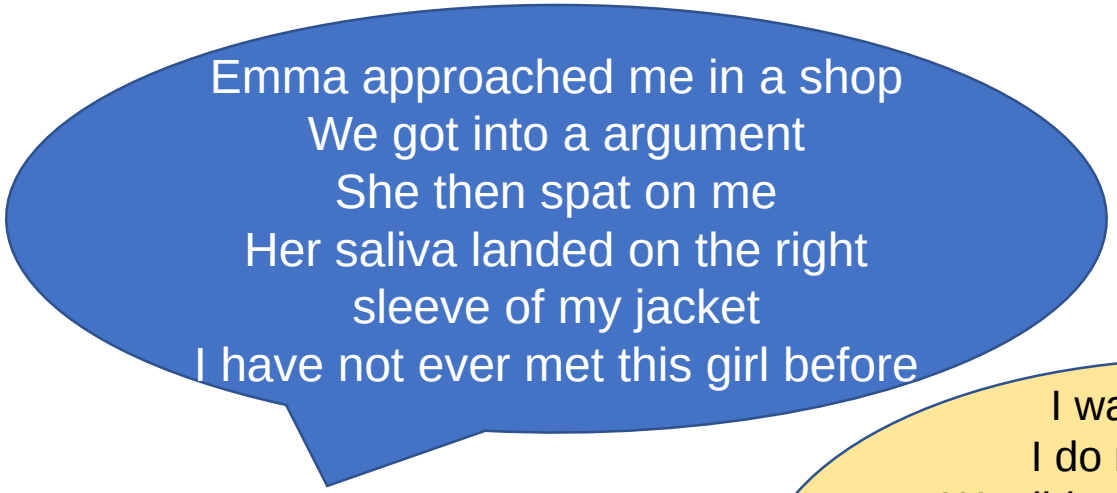
- Demonstrates a clear distinction of roles between the scientist and the court
- Posterior/Prior odds are the domain of the court
- The scientist reports the LR, which updates or informs the prior

Bayes' Theorem

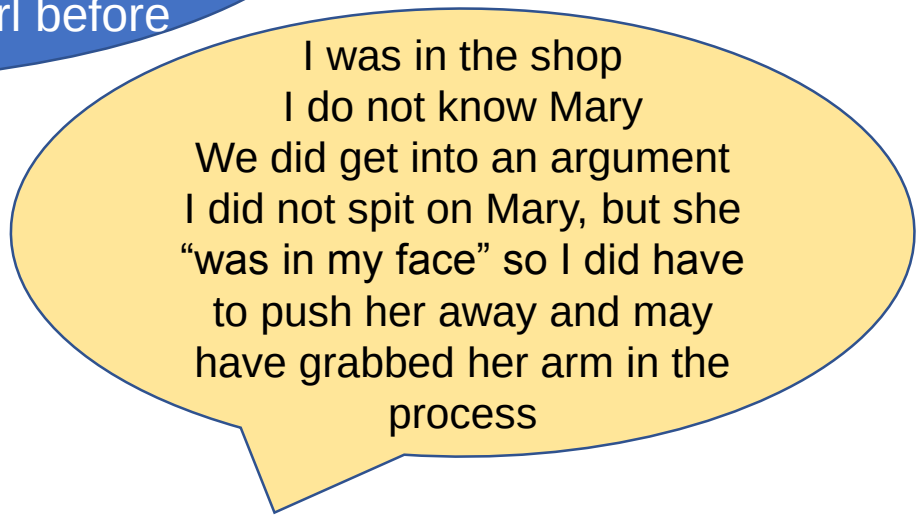
- One of the most important points to consider is that neither proposition has to be true, which is why we use "if" in the LR statement
- The scientist's role is to conduct separate assessments on the DNA results, and inform the prior "if" one proposition is "more true" than the other
- The court ultimately has the big picture (prior evidence) and can decide whether this LR has meaning or not

Think circumstantially and not in absolutes – these DNA results are only one piece of the puzzle

Example



Mary



Emma

H1 proposition: Emma spit on Mary and it landed on her right sleeve

H2 proposition: Emma grabbed Mary’s arm

Expectations

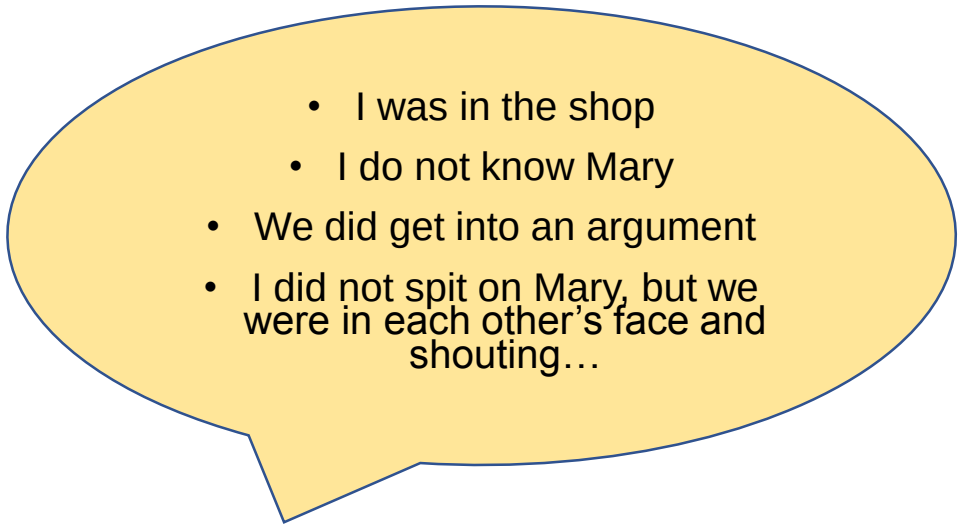
Possible Outcome of Tests (E)	Probability of outcome, assuming truth of Hp Pr [E | Hp, I]	Probability of outcome, assuming truth of Hd Pr [E | Hd, I]	Likelihood Ratio Pr [E | Hp, I] / Pr [E | Hd, I]
Saliva stain on right sleeve; Strong DNA profile matching Emma	**0.95**	**0.05**	**19**
No saliva stain; swab of right sleeve produces weak DNA profile; mixture of Emma/Mary	**0.05**	**0.95**	**0.05**
No saliva stain; No DNA profile produced from swab of right sleeve	**0.001**	**0.001**	**1**
Total	**1**	**1**	**1**

Relevant literature on DNA transfer and saliva would also assist with further informing these probability assignments

Results

- Stain identified on right sleeve (strong amylase positive)
- Strong DNA profile – no indication of a mixture
- When comparing results to expectations, which possible outcome is more likely (expectations closer to observations)?
- Evaluate the findings given the propositions
- “In my opinion, the **probability** of these results are (19X) more likely **if** Emma spit on Mary and it landed on her right sleeve than **if** Emma’s DNA transferred to Mary’s right sleeve from grabbing or pushing.”

What if case information changes?



H1 proposition: Emma spit on Mary and it landed on her right sleeve

H2 proposition: Emma and Mary were arguing and her saliva landed on her sleeve from shouting

Summary

- Activity level reporting is not new, and it matters in our cases
- There are valid concerns with reporting and testifying to these results, so we must use a method that is appropriate and not transpose the conditional
- In court, the best approach when evaluating our results is to use probability as a measure of our uncertainty – the is the Bayesian approach using an LR framework
- The scientist is the best individual to evaluate the scientific results and inform the prior when possible
- This should be based on the findings, associated data and expert knowledge, case specific propositions, and conditioning information

Summary – how do we do it?

$$LR = \frac{\Pr(E \mid H_1, I)}{\Pr(E \mid H_2, I)}$$

- Establish the relevant background case information
- Consider both prosecution and defense accounts
- Consider expectations and perform relevant examinations
- Evaluate the findings in context of the case

Does any of this sound familiar?

Remember the scientific method?

Scientific Inquiry
(5th grade textbook)

1. Ask a question
2. Make a hypothesis
3. Plan and do a test
4. Record and analyze your results
5. Make a conclusion
6. Share your results

Evaluative Reporting

1. How did the DNA transfer?
2. Formulate opposing propositions
3. Pre-assessment (expectations)
4. Examinations (results)
5. Compare observed results to expectations
6. Report and testify in an evaluative manner

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Thank you for your time! Any questions?

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