



Simone Gittelson



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# Reporting LRs - principles



Tacha Hicks-Champod

Franco Taroni



DNA: <http://www.formation-continue-unil-epfl.ch/en/essentials-dna-interpretation>



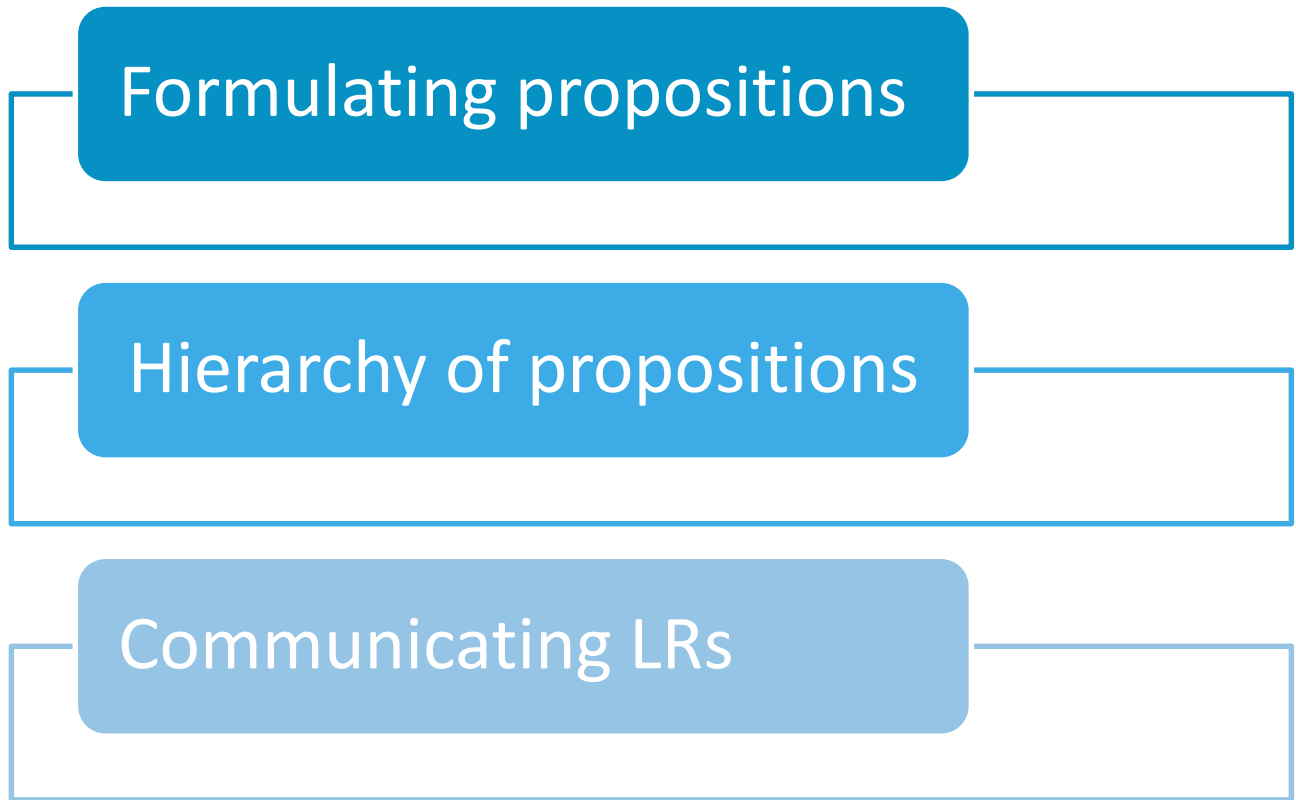
Steven Myers

Tim Kalafut



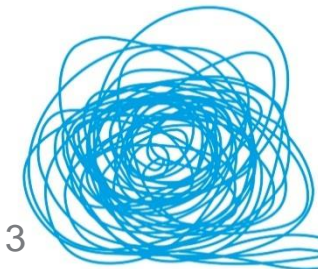
Gittelson S., Kalafut T., Myers S., Taylor D., Hicks T., Taroni F., Evett I.W., Bright J.-A., Buckleton J. (2016) A practical guide for the formulation of propositions in the Bayesian approach to DNA evidence interpretation in an adversarial environment. *Journal of Forensic Sciences* 2016; 61(1): 186-195.

# Hypothesis setting & verbalizing Likelihood Ratios



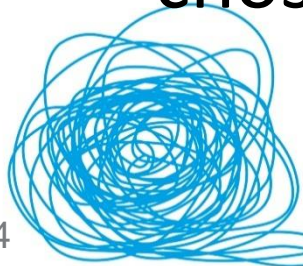
# Setting propositions

- Some useful principles
  - Propositions should be mutually exclusive
  - Propositions should help the Court address the issue of interest
  - Propositions should be (close to) exhaustive



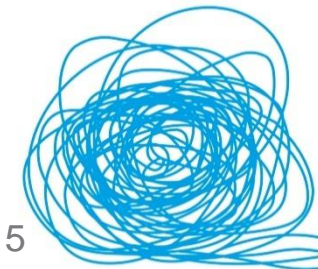
# Setting propositions

- The prosecution proposition ( $H_p$ ) is usually known
- In an adversarial environment the defence are under no requirement to offer a proposition and often they do not
- If the defence stance is available that can be selected, if not, a sensible proposition consistent with the best defence can be chosen



# Setting propositions

- Set based on *relevant* case information, including
  - Alleged activities, location of scene, consensual partners
- Ignore (actually do not want) irrelevant detail, including
  - Prior convictions, motive, other forensic evidence
  - Responsibility of judge/jury to evaluate



# Hierarchy of propositions

3. Offence

- Guilt or innocence. e.g.  $H_p$  “The suspect raped the victim”

2. Activity

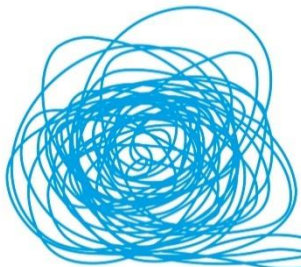
- e.g.  $H_p$  “The POI had intercourse with the complainant”

1. Source

- e.g.  $H_p$  “The semen came from the POI”

0. Sub-source

- e.g.  $H_p$  “The DNA in the sample came from the POI”



# Hierarchy of propositions

3. Offence

The **offense level** is usually not the realm of the forensic scientist. This is for the court to decide based on all the available information presented

2. Activity

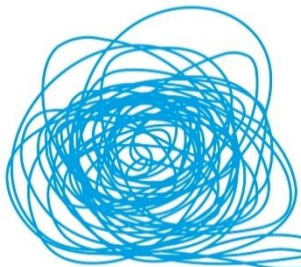
There may be occasions when a reporting scientist can address the **activity level**, based on their experience and available literature

1. Source

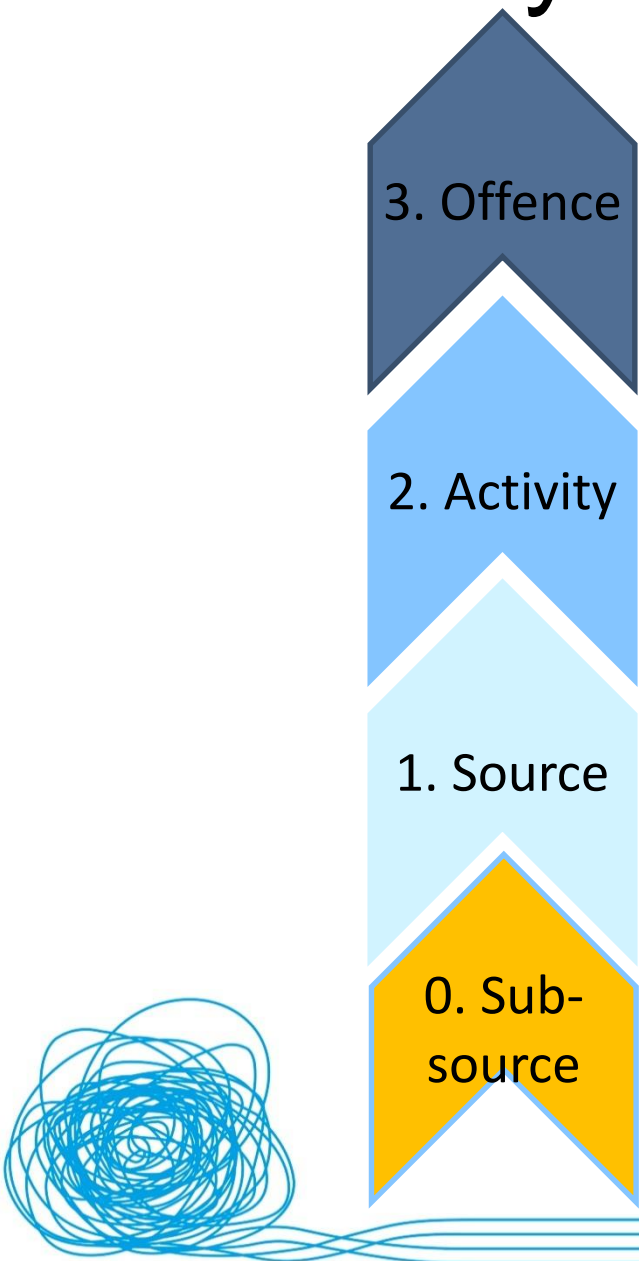
In some instances it may be possible to step up to body fluid attribution & hence report at the **source level**

0. Sub-source

A DNA reporting analyst will spend most of their time at the **sub-source level**



# Hierarchy of propositions



Transition from sub-source to activity

- In practice many lines of questioning concede the source of the DNA and instead focus on transfer & persistence
- Should both parties agree the DNA came from an individual then the *LR* at (sub) source level is no longer relevant

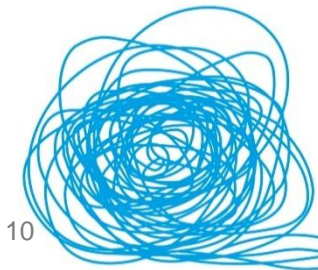


# Hierarchy of propositions

- Cook, R., et al., A hierarchy of propositions: Deciding which level to address in casework. *Science and Justice*, 1998. 38(4): p. 231-240.
- Evett, I.W., G. Jackson, and J.A. Lambert, More on the hierarchy of propositions: exploring the distinction between explanations and propositions. *Science & Justice*, 2000. 40(1): p. 3 - 10.
- Evett I.W. et al., Interpreting small quantities of DNA: the hierarchy of propositions and the use of Bayesian networks. *Journal of Forensic Science*. 2002;47(3):520-30.
- Buckleton J.S., Bright J.-A., Taylor D., Evett I.W., Hicks T., Jackson G., Curran J.M. Helping formulate propositions in forensic DNA analysis. (2014) *Science & Justice* 54(4) 258-261

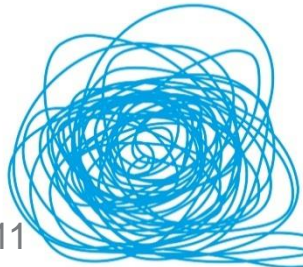


# Proposition settings exercise



# Example 1

- Scenario: a “Peeping Tom” is discovered looking into a house one night. The police are called and find a single cigarette butt under the window where the incident occurred.
- Single source profile from a cigarette butt
- One person of interest (POI), reference corresponds with profile from cigarette butt



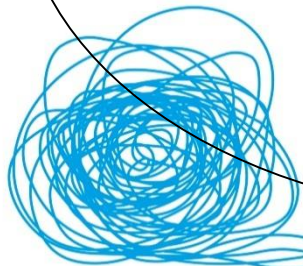


The evidence  
came from the POI

Prosecutor

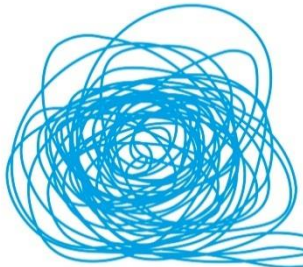
The evidence  
came from an  
unknown person  
unrelated to the  
POI

Defense



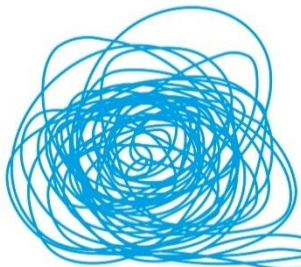
$H_p$ : POI

$H_d$ : Unknown



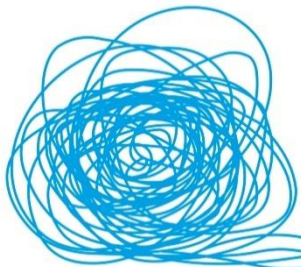
## Example 2

- Scenario: A complainant calls 911 to report a sexual assault in her home. She is taken to a hospital where a SA Nurse collects an intimate swab from the complainant.
- A POI is identified from the investigation
- The profile is fully explained by a mixture of C and POI



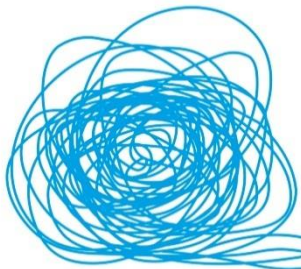
## Example 2

- An intimate swab from the Complainant
- Profile is fully explained by mixing of C and POI's DNA
- Direction of transfer vital
  - $H_p$ : Complainant + POI
  - $H_d$ : Complainant + Unknown



## Example 3

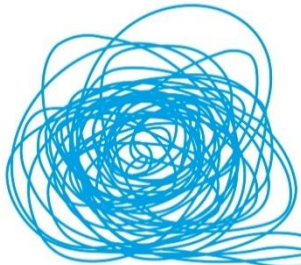
- Scenario: Assault male on female.
- A POI is identified from the investigation
- Mixed profile on underwear of POI. The profile is fully explained by a mixture of C and POI





## Example 3

- Underwear of POI
- Profile is fully explained by mixing of C and POI's DNA
- Direction of transfer vital
  - $H_p$ : Complainant + POI
  - $H_d$ : POI + Unknown



# Example 5

- Someone has been throwing Molotov cocktails at random cars all over the county. An unexploded container is found in the street, and a 2 person mixture is developed from the evidence.
- Two persons of interest are arrested.



# Example 5

$H_p$ : POI(1) + POI(2)

$H_d$ : POI(1) + an unknown person

or

$H_p$ : POI(1) + POI(2)

$H_d$ : POI(2) + an unknown person

or

$H_p$ : POI(1) + POI(2)

$H_d$ : 2 Unknown people

POI(2) on trial and  
concede POI(1) present?

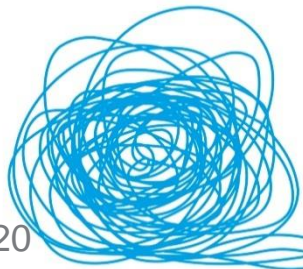
POI(1) on trial and  
concede POI(2) present?

Circumstances indicate  
both or neither?

Assuming they are both present,  
this LR will be huge

# Diversity in the US

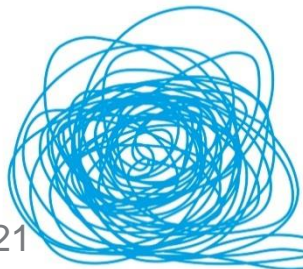
$P_1 + U / 2U$ (report)	$P_1 + U / 2U$ (warm up)
$P_2 + U / 2U$ (report)	$P_2 + U / 2U$ (warm up)
$P_1 + P_2 / 2U$ (in file)	$P_1 + P_2 / P_2 + U$ (report)
	$P_1 + P_2 / P_1 + U$ (report)



	$P_1$	$P_2$
$P_x+U / 2U$	3.39E+23	5.67E+33
$P_1+P_2 / P_x+U$	1.90E+24	2.23E+34
$P_1+P_2 / 2U$	5.23E+57	

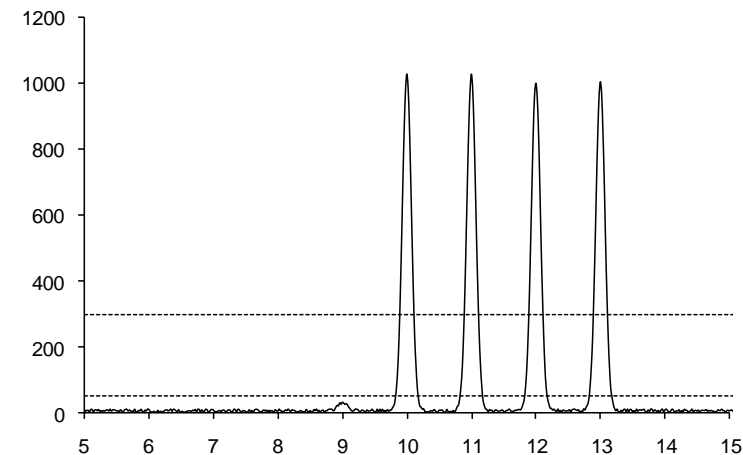
$P_1$	$P_2$
8.90E+03	1.36E+22
3.11E+08	5.64E+26
1.04E+30	

Credit Dr Hannah Kelly



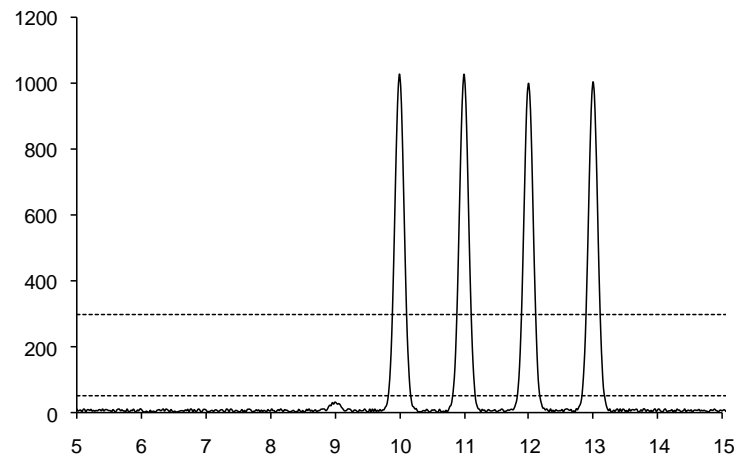
# Example 6

- Scenario: A complainant walking through a city park is attacked from behind and is sexually assaulted on a blanket.
- Complainant = 10,11
- Person of interest = 12,13
- Profile is fully explained by mixing of C and POI's DNA



# Example 6

- I: a blanket in a park where an alleged rape occurred
- Complainant = 10,11
- Person of interest = 12,13
- Profile is fully explained by mixing of C and POI's DNA



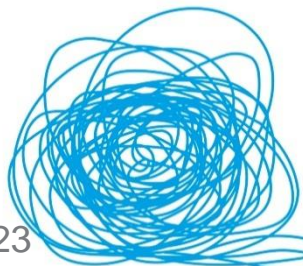
$H_p$ : C + POI

$H_d$ : ?

$H_{d1}$ : C + Unknown

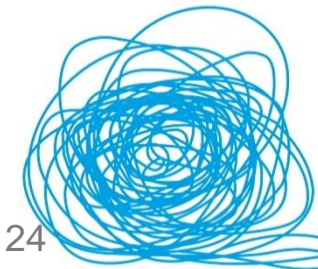
$H_{d2}$ : Unknown + POI

$H_{d3}$ : Unknown + Unknown



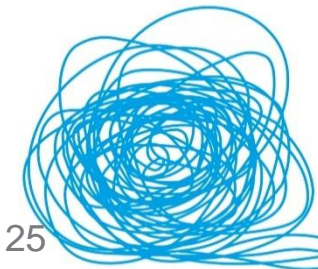
# Example 6

- Statement
  - $H_p$ : The DNA came from Complainant + POI
  - $H_d$ : I have considered whether the DNA came from Complainant + Unknown, or POI + Unknown or 2 Unknowns
  - The  $LR$  is at least ....

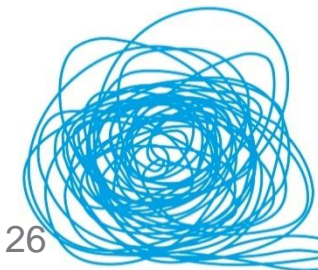




**Example 7.** Consider a multiple homicide where four people,  $D_1, \dots, D_4$ , are killed. A blood stain is recovered from the address of the person of interest. This stain appears to arise from four contributors and can be fully explained by  $D_1, \dots, D_4$ .



**Example 8.** A woman, C, attends a party at a gang house which is next door to her own house. She states that she was raped by POI in her own bed the following morning. POI states that he had consensual sex with her on his bed and then more consensual sex with her in her bed the next morning. A stain is analyzed from the sheet of POI's bed. This can be explained as a mixture of C, POI, and female A. Female A is the usual partner of POI.



**Example 9.** The complainant states that she was raped at her home by POI after a drunken party. POI matches the DNA from the complainant's cervical swab. No statement is available from the defense at the time of analysis. The reporting officer proceeds with the propositions:

Hp sub-source: The DNA came from POI (or C and POI if it is a mixture)

Hd sub-source: The DNA came from U (or C and U if it is a mixture)

The reporting officer assigns and reports an  $LR_{\text{sub-source}}=10^9$ .

At trial, the defense said that POI had previously masturbated and cleaned up with the last of the toilet paper on the roll and threw it in trash can next to toilet. Defense suggest that C used the toilet, realized there was no toilet paper on the roll, so she must have reached into the trash and used that toilet paper.

# $H_p$ and $H_d$

What about brothers or  
cousins?



This is not a problem specific to  
LRs, however, LR's can  
accommodate this



$H_p$  and  $H_d$

What if my defence is that the DNA got there by some other means?



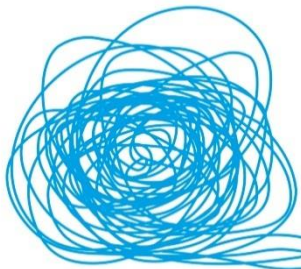
Then  $H_p$  and  $H_d$  both say the DNA came from Mr Smith.  
The discussion moves to transfer and contamination



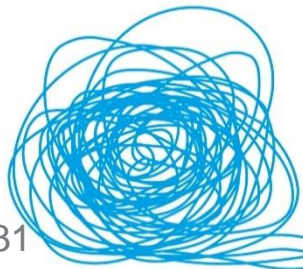
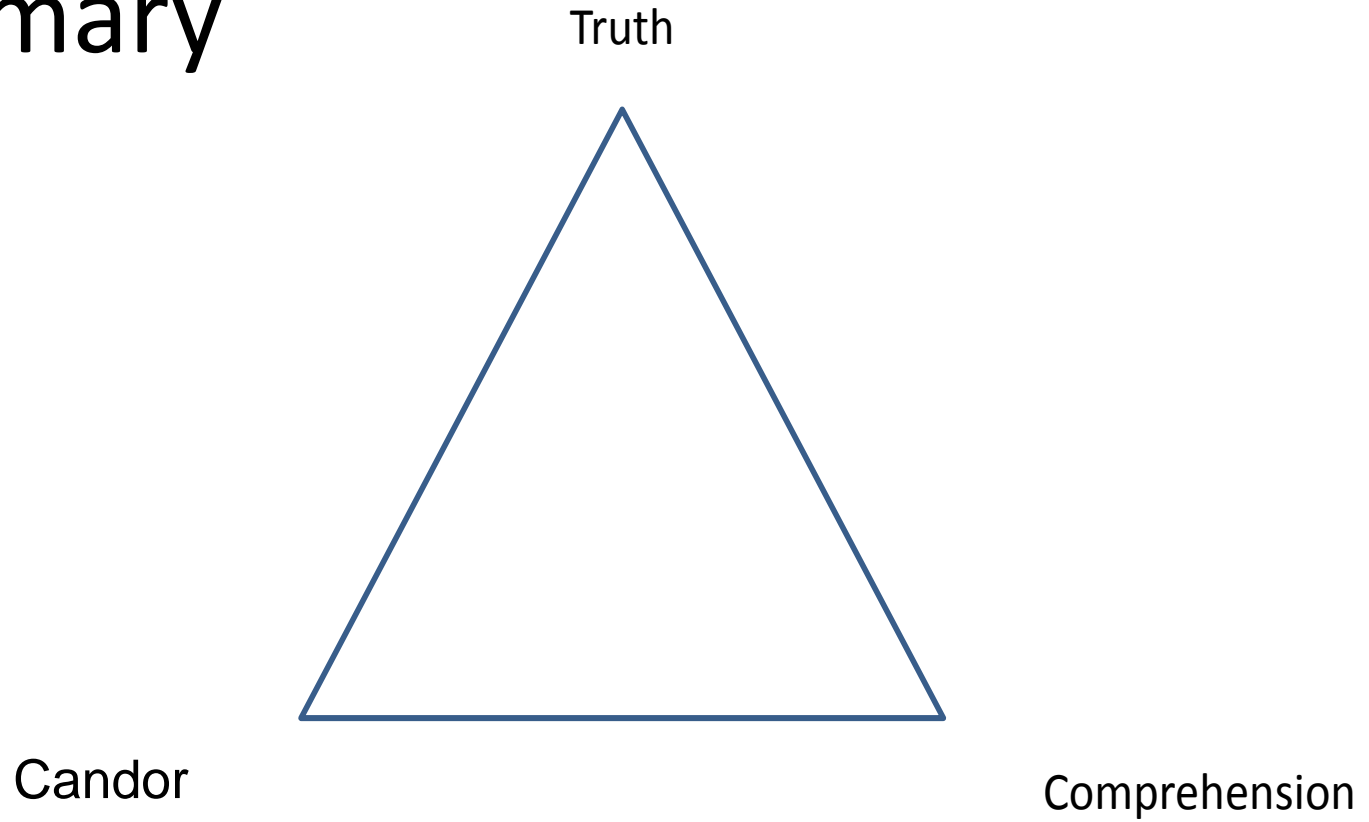
# Reporting the likelihood ratio

- How do we communicate this number?
- “The *evidence* is a billion times more likely *if* the person of interest is the donor of the stain than if a random, unrelated person is the donor of the stain”

$$\frac{\Pr(E | H_p)}{\Pr(E | H_d)}$$

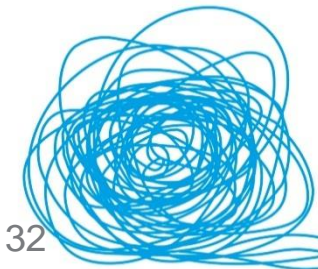


# Summary



# Avoiding Logical Fallacies

- Prosecutors fallacy
- Defence fallacy
- Uniqueness fallacy

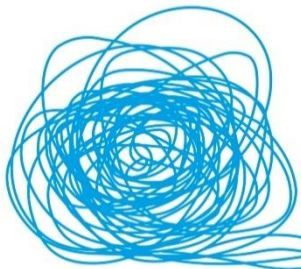


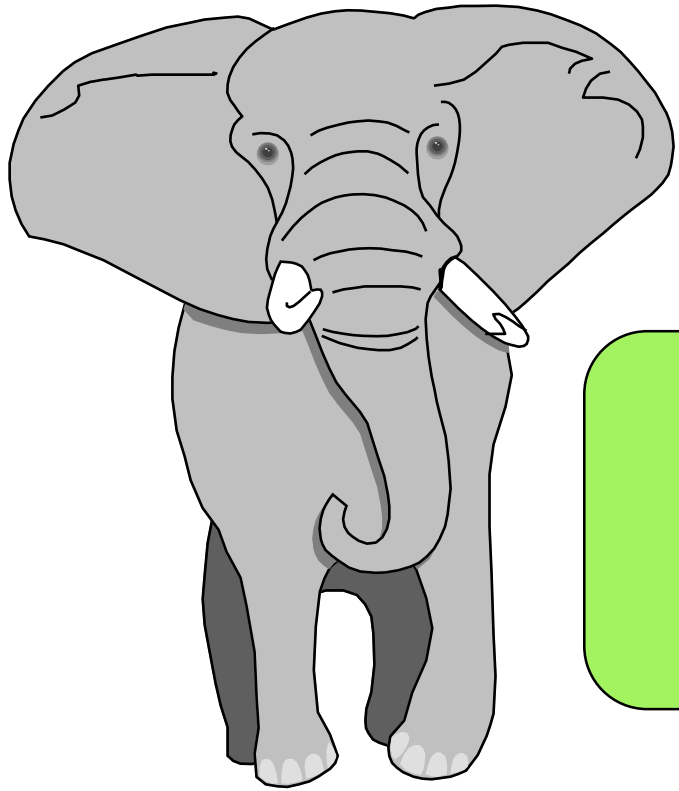


# Prosecutor's Fallacy

The fallacy is to transpose the conditional:

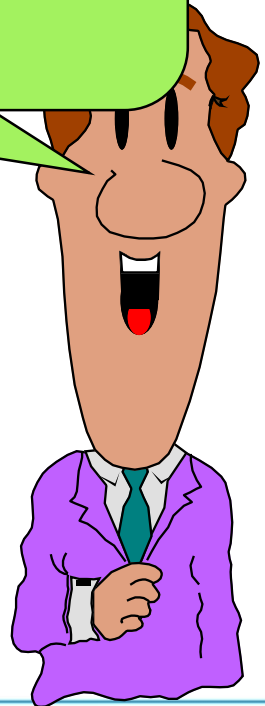
$$\Pr(E|H_d, I) = \Pr(H_d|E, I)$$





*there is a very high probability  
that an animal has four legs  
if it is an elephant*

$$\text{Pr}(\text{Four legs} \mid \text{Elephant}) = 0.9999$$



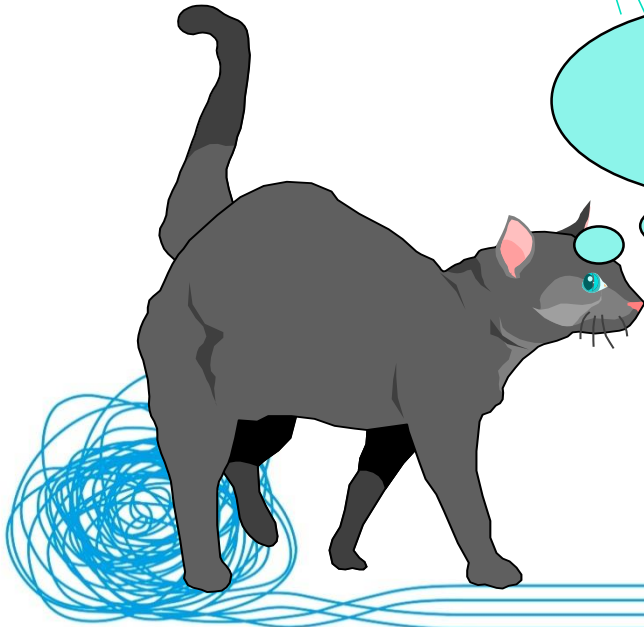
SO!! - there is a very high probability that an animal is an elephant if it has four legs.



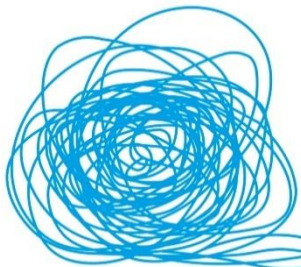
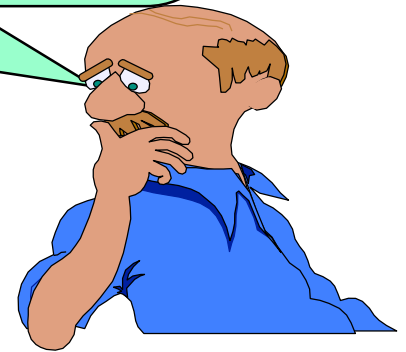
$$\Pr(\text{Four legs} \mid \text{Elephant}) = 0.9999$$

$$\Pr(\text{Elephant} \mid \text{Four legs}) = 0.9999$$

???



Examples about elephant's legs may seem easy to follow - but it's often not so easy in court proceedings.

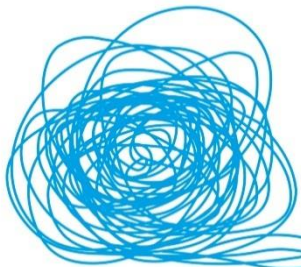
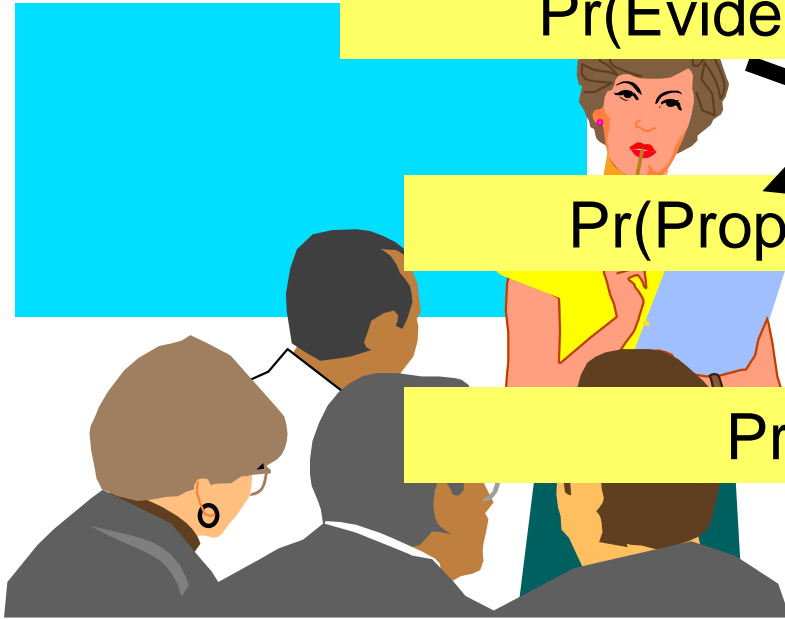


Stella's spotting trick

$\Pr(\text{Evidence} \mid \text{Proposition}) = \text{Correct}$

$\Pr(\text{Proposition} \mid \text{Evidence}) = \text{Incorrect}$

$\Pr(\text{Proposition}) = \text{Incorrect}$



Pr

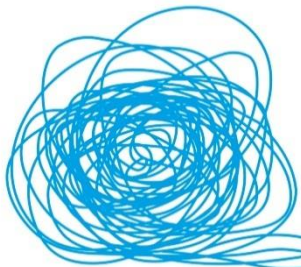
The probability that the DNA came from someone else is very low

Proposition

$H_2$ : The DNA came from someone else

$\Pr [E | H_2]?$

$\Pr [ H_2 | E ]$  or  $\Pr( H_2 )?$

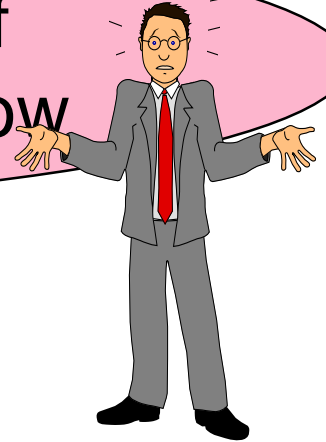


Pr

E : This DNA profile

I

The probability of this DNA profile if it came from someone else is very low



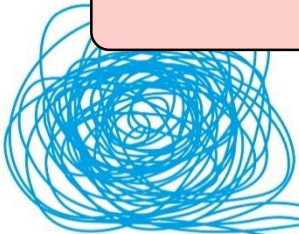
Proposition?

$H_2$ : The DNA came from someone else

E : This DNA profile

Pr [E| $H_2$ ]?

Pr [  $H_2$ |E] or Pr( $H_2$ )?



# Prosecutor's Fallacy

$$\Pr(E|H_d, I) = 1 \text{ in } 7 \text{ million}$$



~~In layman's terms, just so I get this right, are you saying that the probability that the DNA that was found in the question samples came from anyone else besides A.L. is one in 7 million (...)?~~

Pr

Proposition

State v. Lee, No. 90CA004741 (Ohio App. Dec. 5, 1990), transcript at 464





# Prosecutor's Fallacy

$$\Pr(E|H_d, I) = 1 \text{ in } 10 \text{ million}$$

~~The witness concludes that the genetic profile of the two analyzed samples match perfectly, and he deduces that~~

Pr the probability of someone other than the suspect being the source of the trace ~~found on the victim's clothes~~ is 1 in 10 million.

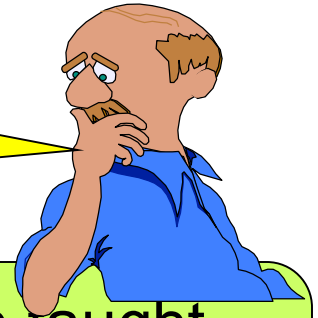
Proposition

modified from:

State of Arizona v. Michael Steven Gallegos [178 Ariz. 1; 870 P.2d 1097 (1994)]



So you mean.....some ambiguous sentence



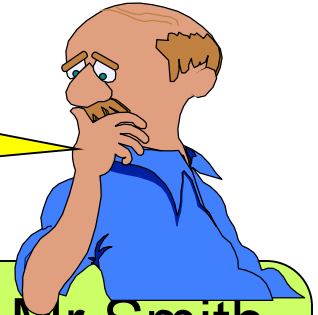
As forensic scientists we have been taught to be very careful about the wording of probability statements...

Subtle misstatements have led To misunderstanding in the past...

...I'm unsure about the exact wording of your sentence. I am trained to give you some that are known to be correct



Please go ahead and give me some



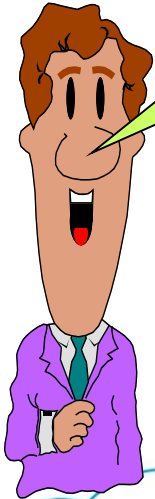
A statement about the probability that Mr Smith left the stain can only be made from all the evidence, not from the DNA alone.

The DNA evidence by itself increases the odds that Mr Smith is the donor LR times Over what they would be from the other evidence

This represents extremely strong support that he is the donor



Evidence of this strength would occur less than  
1 in LR of the time from a random donor



# Defense Attorney's Fallacy

$$\Pr(E|H_d, I) = 1 \text{ in } 1,000$$



The city where the crime occurred has a population of 200,000. In this city, this genotype would be found in 200 people. Therefore the evidence merely shows that the person of interest is one of 200 people in the city who might have left the crime stain.



# Defense Attorney's Fallacy

The fallacy is:

1. 200 individuals in the population plus the genotyped POI is equal to 201
2. To assume that each of these 200 individuals has the **same prior probability** of being the source of the crime stain as the POI
3. To assume that the **actual** number of individuals in this city having the genotype in question is equal to the **expected** number of individuals having this genotype. The actual number could be anywhere between 1 and 200,000.



# Correct

$$\Pr(E|H_d, I) = 1 \text{ in } 1,000$$



The city where the crime occurred has a population of 200,000. In this city, we would **expect** to find this genotype in 200 untyped people in addition to the POI.

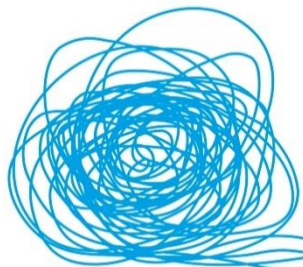


# Uniqueness Fallacy

$$\Pr(E|H_d, I) = 1 \text{ in } 200,000$$



The city where the crime occurred has a population of 200,000. In this city, this genotype can therefore only come from the person of interest.

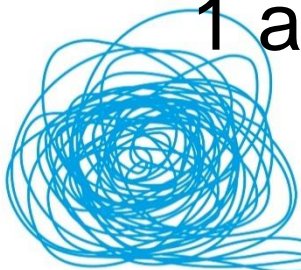




# Uniqueness Fallacy

The fallacy is:

1. 1 individual in the population plus the genotyped POI is equal to a total of two individuals
2. To assume that the **actual number** of individuals in this city having the genotype in question is equal to the **expected number** of individuals having this genotype. The actual number could be anywhere between 1 and 200,000.

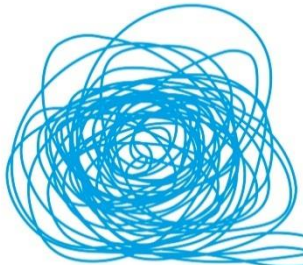


# Correct

$$\Pr(E|H_d, I) = 1 \text{ in } 200,000$$



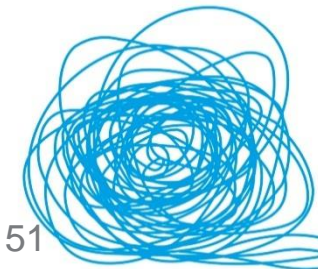
The city where the crime occurred has a population of 200,000. In this city, we would **expect** to find this genotype in 1 untyped person in addition to the POI.



# Verbal scales

## Should I report a verbal equivalent?

- Verbal impression of the weight of evidence
- This association of words with numbers is subjective and necessarily arbitrary



# Verbal scales to express LR s

## *Verbal “equivalent”*

## *Likelihood Ratio*

provides extremely strong support [for  $H_1$ ]

over 1,000,000

provides very strong support [for  $H_1$ ]

1000-1,000,000

provides strong support [for  $H_1$ ]

100-1000

provides moderate support [for  $H_1$ ]

10-100

provides slight support [for  $H_1$ ]

1-10

is neutral

1

provides slight support [against  $H_1$ ]

1-0.1

provides moderate support [against  $H_1$ ]

0.1-0.01

provides strong support [against  $H_1$ ]

0.01-0.001

provides very strong support [against  $H_1$ ]

0.001-0.000001

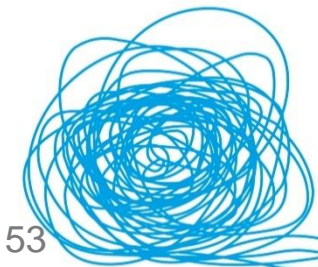
provides extremely strong support [against  $H_1$ ]

less than 0.000001



Numerical Value	1	1-10	10 - 100	100 - 1000	1000 - 10 000	10 000 - 100 000	100 000 - 1 million	> 1 million
<b>Evetts and Buckleton [29]</b>		Slightly supports	Supports	Strongly supports	Very strongly supports			
<b>Buckleton et al. [30]</b>	Inconclusive	Limited		Moderate	Moderately strong	Strong	Very Strong	Extremely strong
<b>Evetts and Weir [2]</b>		Limited	Moderate	Strong	Very strong			
<b>Australian Forensic labs</b>	Neutral	Slight			Very strong			

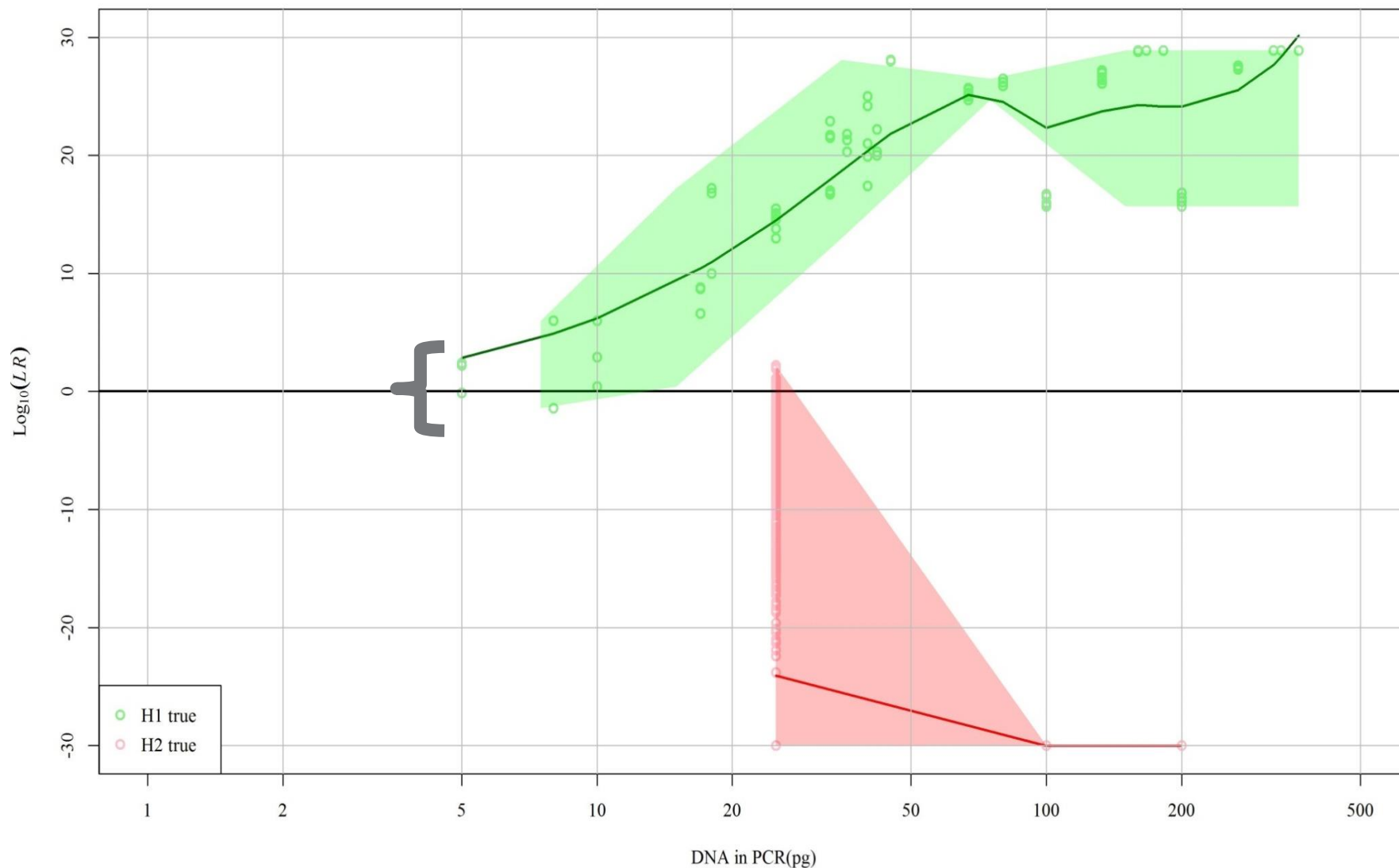
*Association of words with numbers is subjective*



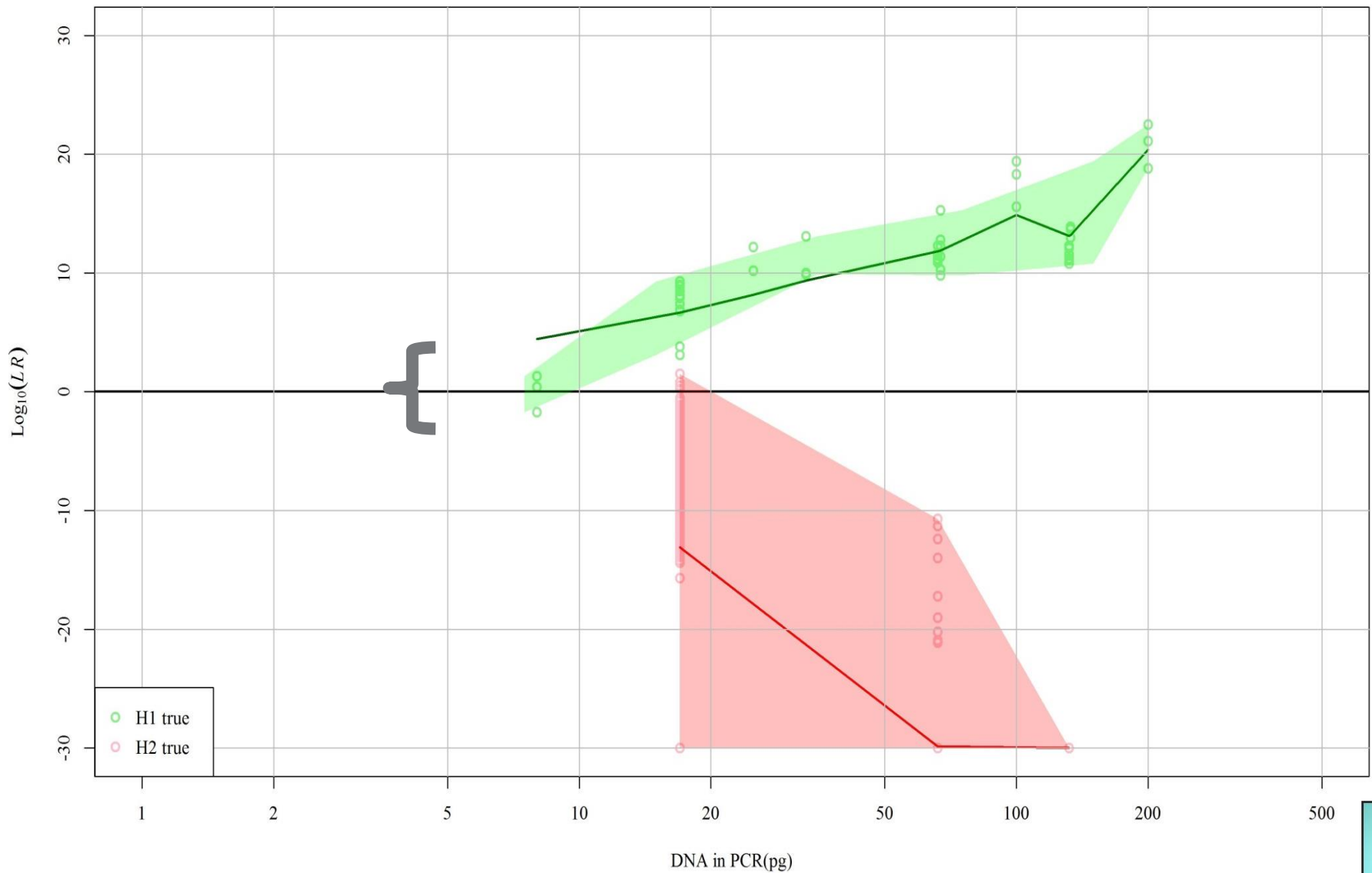
	LR = 0	-8 to -7	-7 to -6	-6 to -5	-5 to -4	-4 to -3	-3 to -2	-2 to -1	-1 to 0	0	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	
Marquis et al [92]										nu	w or l	m	ms	st	vs	es	es	es	es	es	es	es
John Buckleton	e	e	e	e	e	e	u	u	u	u	u	u	u	st	vs	es	es	es	es	es	es	es
US lab 1										ns	slight	m	st	vs	vs	vs	es	es	es	es	es	es
Evetts et al [94]											l	m	ms	st	vs	vs	es	es	es	es	es	es
Martire & Watkins [95]											w or m	m	ms	st	vs	vs	es	es	es	es	es	es
ENSFI		es	es	vs	vs	s	ms	m	sl or l	na	sl or l	m	ms	st	vs	vs	es	es	es	es	es	es
US lab 2		es	es	vs	vs	s	ms	m	sl or l	u	u	u	ms	st	vs	vs	es	es	es	es	es	es
US lab 3 Fusion 6C	e	e	e	e	e	e	u	u	u	u	u	u	u	l	m	st	es	es	es	es	es	es
US lab 4 Id+	e	e	e	e	e	e	u	u	u	u	u	u	l	m	st	st	es	es	es	es	es	es
US lab 5										n	u	w	m	st	st	st	vs	vs	vs	es	es	es
Evetts & Weir [96]											l	m	st	vs	vs	vs	vs	vs	vs	vs	vs	vs
US lab 6	e	e	e	e	e	e	u	u	u	u	u	u	l	m	st	st	vs	vs	vs	vs	vs	vs
US lab 7	e	e	e	e	e	e	e	e	e	u	u	sl	sl	st	st	st	st	vs	vs	vs	vs	vs
US lab 8 (5 person mixtures)	e	e	e	e	e	e	e	u	u	u	u	u	l	m	st	st	st	st	st	st	st	st
US lab 8 (single source to four)	e	e	e	e	e	e	u	u	u	u	u	u	u	m	st	st	st	st	st	st	st	st
US lab 9	s	s	m	m	m	m	w	w	u	u	u	w	w	m	m	m	m	st	st	st	st	st
US lab 10	e	sn	sn	sn	sn	sn	u	u	u	u	u	u	u	su	su	su	su	su	su	su	su	su
US lab 11	e	e	e	e	e	e	e	i	i	i	i	i	su	su	su	su	su	su	su	su	su	su
US lab 12	e	e	e	e	e	e	e	i	i	i	i	i	su	su	su	su	su	su	su	su	su	su

# 2 person mixtures

The purists would strongly disagree but...

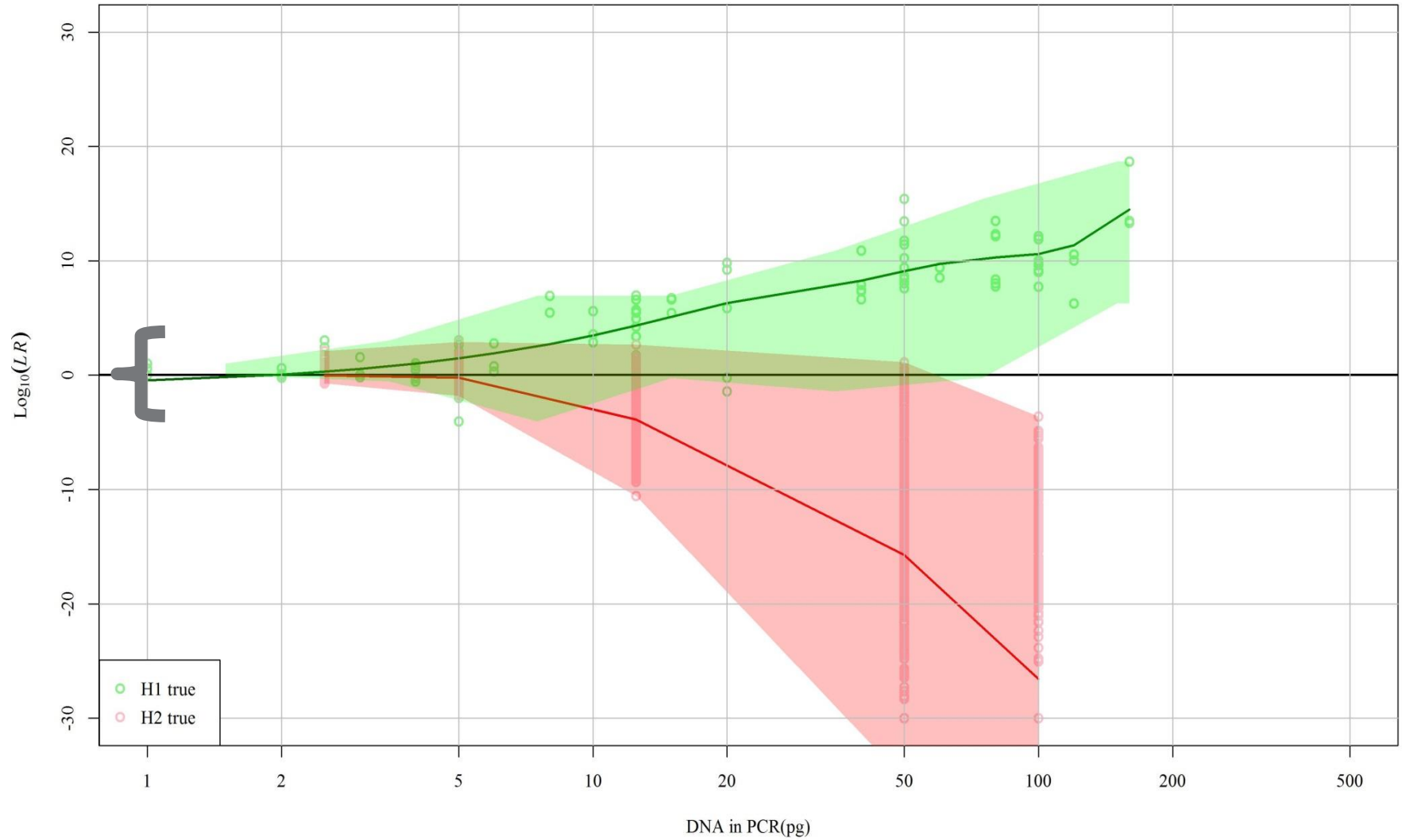


# 3 person mixtures



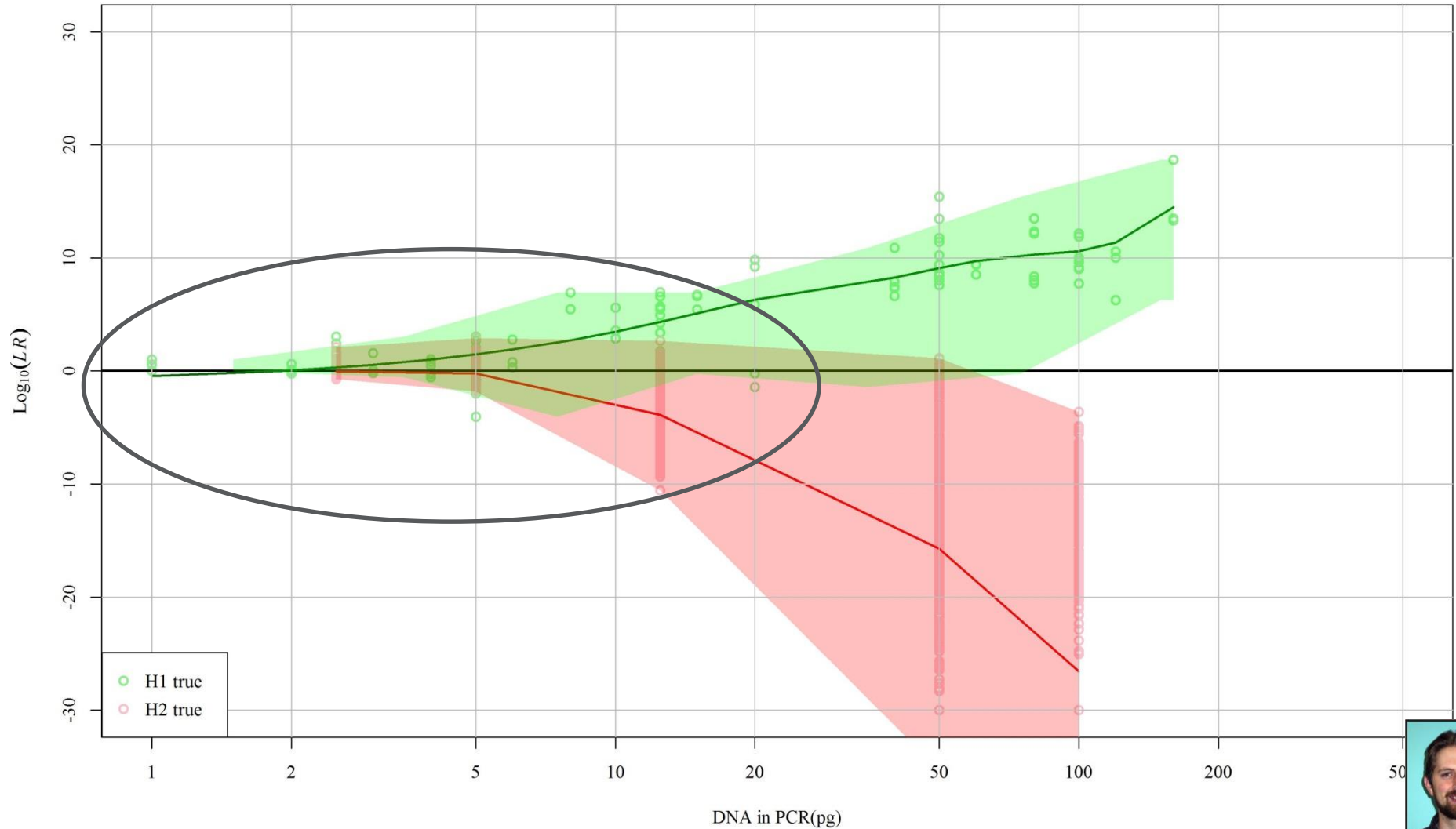


# 4 person mixtures

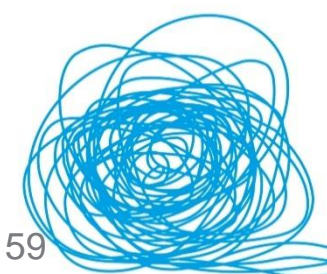


# 4 person mixtures

Unreliable?  
Inconclusive?  
No - uninformative



pro	con
Gives the correct "feel"	Chr -Y
Lowers CSI effect	Other evidence types
	Distain from purists



# Should I report a verbal equivalent?

- Yes. The verbal scale is helpful for the jury to put the *LR* into perspective (particularly low level evidence)
- No. The verbal scale is not the responsibility of the forensic science (and can be a plaything of lawyers)

