# Forensic Genetics

Module 16 – Section 8 Exercises

# Exercise 1a: LR – Relatives

Consider a simple single-source crime scene sample with genotype $G_C = AA$, and a suspect that matches at that locus. Calculate the LR, using $p_A = 4\%$, and alternative hypotheses:

- The DNA in the sample came from a brother of the suspect;

# Exercise 1a: LR – Relatives

Consider a simple single-source crime scene sample with genotype $G_C = AA$, and a suspect that matches at that locus. Calculate the LR, using $p_A = 4\%$:

- LR $= \frac{1}{0.25p_A^2+0.5p_A+0.25} \approx 3.7$;

# Exercise 1b: LR – Relatives

Consider a simple single-source crime scene sample with genotype $G_C = AA$, and a suspect that matches at that locus. Calculate the LR, using $p_A = 4\%$, and alternative hypotheses:

- The DNA in the sample came from a brother of the suspect;
- The DNA in the sample came from an identical twin of the suspect.

# Exercise 1b: LR – Relatives

Consider a simple single-source crime scene sample with genotype $G_C = AA$, and a suspect that matches at that locus. Calculate the LR, using $p_A = 4\%$:

- LR $= \frac{1}{0.25p_A^2+0.5p_A+0.25} \approx 3.7$;

- LR $= 1$.

# Exercise 2a: Paternity Index

Suppose a child has genotype $G_C = AB$. What are the LR values when:

- $G_M = AA$ and $G_{AF} = BB$;

# Exercise 2a: Paternity Index

Suppose a child has genotype $G_C = AB$. The LR values are:

- LR $= \frac{\Pr(G_C=AB|G_M=AA,G_{AF}=BB,H_p)}{\Pr(G_C=AB|G_M=AA,H_d)} = \frac{1}{p_B}$;

# Exercise 2a: Paternity Index

Suppose a child has genotype $G_C = AB$. What are the LR values when:

- $G_M = AA$ and $G_{AF} = BB$;
- $G_M = AA$ and $G_{AF} = CD$;

# Exercise 2a: Paternity Index

Suppose a child has genotype $G_C = AB$. The LR values are:

- $\text{LR} = \frac{\Pr(G_C{=}AB|G_M{=}AA{,}G_{AF}{=}BB{,}H_p)}{\Pr(G_C{=}AB|G_M{=}AA{,}H_d)} = \frac{1}{p_B}$;

- $\text{LR} = \frac{\Pr(G_C{=}AB|G_M{=}AA{,}G_{AF}{=}CD{,}H_p)}{\Pr(G_C{=}AB|G_M{=}AA{,}H_d)} = 0$;

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- $G_M = AA$ and $G_{AF} = BB$;
- $G_M = AA$ and $G_{AF} = CD$;
- $G_M = AA$ and $G_{AF} = BC$;

# Exercise 2a: Paternity Index

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- $\text{LR} = \frac{\Pr(G_C{=}AB|G_M{=}AA,G_{AF}{=}BB,H_p)}{\Pr(G_C{=}AB|G_M{=}AA,H_d)} = \frac{1}{p_B};$
- $\text{LR} = \frac{\Pr(G_C{=}AB|G_M{=}AA,G_{AF}{=}CD,H_p)}{\Pr(G_C{=}AB|G_M{=}AA,H_d)} = 0;$
- $\text{LR} = \frac{\Pr(G_C{=}AB|G_M{=}AA,G_{AF}{=}BC,H_p)}{\Pr(G_C{=}AB|G_M{=}AA,H_d)} = \frac{\frac{1}{2}}{p_B} = \frac{1}{2p_B};$

# Exercise 2a: Paternity Index

Suppose a child has genotype $G_C = AB$. What are the LR values when:

- $G_M = AA$ and $G_{AF} = BB$;
- $G_M = AA$ and $G_{AF} = CD$;
- $G_M = AA$ and $G_{AF} = BC$;
- $G_M = AB$ and $G_{AF} = AA$.

# Exercise 2a: Paternity Index

Suppose a child has genotype $G_C = AB$. The LR values are:

- LR $= \frac{\Pr(G_C=AB|G_M=AA,G_{AF}=BB,H_p)}{\Pr(G_C=AB|G_M=AA,H_d)} = \frac{1}{p_B}$;

- LR $= \frac{\Pr(G_C=AB|G_M=AA,G_{AF}=CD,H_p)}{\Pr(G_C=AB|G_M=AA,H_d)} = 0$;

- LR $= \frac{\Pr(G_C=AB|G_M=AA,G_{AF}=BC,H_p)}{\Pr(G_C=AB|G_M=AA,H_d)} = \frac{\frac{1}{2}}{p_B} = \frac{1}{2p_B}$;

- LR $= \frac{\Pr(G_C=AB|G_M=AB,G_{AF}=AA,H_p)}{\Pr(G_C=AB|G_M=AA,H_d)} = \frac{\frac{1}{2}}{\frac{1}{2}p_A+\frac{1}{2}p_B} = \frac{1}{p_A+p_B}$.

# Exercise 2b: Paternity Index

Calculate the weight of the evidence for the following data:

| **Locus** | $G_C$ | $G_M$ | $G_{AF}$ |
|---|---|---|---|
| TPOX | (6,9) | (6,12) | (8,9) |
| vWA | (17,17) | (17,16) | (17,17) |
| TH01 | (7,9) | (9,10) | (7,9) |

| **Locus** | **Allele** | **Frequency** |
|---|---|---|
| TPOX | 6 | 0.006 |
| | 8 | 0.506 |
| | 9 | 0.094 |
| | 12 | 0.038 |
| vWA | 16 | 0.276 |
| | 17 | 0.300 |
| TH01 | 7 | 0.147 |
| | 9 | 0.232 |
| | 10 | 0.116 |

Source: Introduction to Statistics for Forensic Scientist (Lucy, 2005).

# Exercise 2b: Paternity Index

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We calculate single-locus LRs and combine these results through multiplication:

- TPOX: LR $= \frac{0.25}{0.5p_9} = \frac{1}{2\times 0.094} = 5.32$;
- vWA: LR $= \frac{1}{p_{17}} = \frac{1}{0.3} = 3.33$;
- TH01: LR $= \frac{0.25}{0.5p_7} = \frac{1}{2\times 0.147} = 3.40$.

Our overall LR is in this case 60.23, yielding evidence in favor of $H_p$.

# Exercise 3a: Missing Persons

For a missing person case, the two propositions could be:

$H_p$: The sample is from the missing person.
$H_d$: The sample is from some unknown person.

The following likelihood ratios are obtained for a sample with alleged mother (AM) and alleged father (AF), compared to the paternity index, for $p_A = p_B = 0.1$:

| (A)M | AF | Sample | LR | Value | PI | Value |
|---|---|---|---|---|---|---|
| $AA$ | $BB$ | $AB$ | | | | |
| $AA$ | $BC$ | $AB$ | | | | |
| $AB$ | $AA$ | $AB$ | | | | |

Source: Interpreting DNA Evidence (Evett & Weir, 1998).

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The following likelihood ratios are obtained for a sample with alleged mother (AM) and alleged father (AF), compared to the paternity index, for $p_A = p_B = 0.1$:

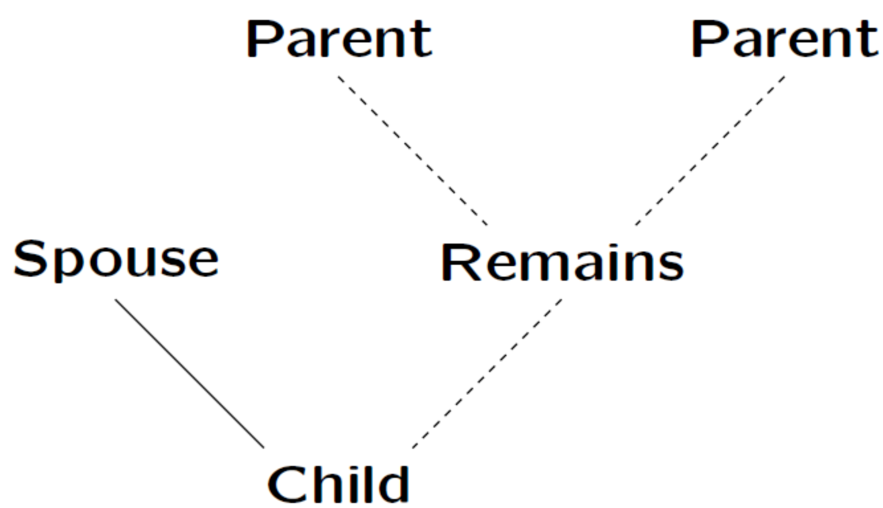
| (A)M | AF | Sample | LR | Value | PI | Value |
|---|---|---|---|---|---|---|
| $AA$ | $BB$ | $AB$ | $\frac{1}{2p_Ap_B}$ | 50 | $\frac{1}{p_B}$ | 10 |
| $AA$ | $BC$ | $AB$ | $\frac{1}{4p_Ap_B}$ | 25 | $\frac{1}{2p_B}$ | 5 |
| $AB$ | $AA$ | $AB$ | $\frac{1}{4p_Ap_B}$ | 25 | $\frac{1}{p_A+p_B}$ | 5 |

Source: Interpreting DNA Evidence (Evett & Weir, 1998).

# Exercise 3b: Missing Persons

It may be the case that people apart from the spouse and child of the missing person are typed. The general procedure is the same: the probabilities of the set of observed genotypes under two explanations are compared.

Suppose the parents $P$ and $Q$ as well as the child $C$ and spouse $S$ of the missing person are typed, and that a sample is available that has come from some person $X$ thought under $H_p$ to be the missing person.



# Exercise 3b: Missing Persons

Under explanation $H_d$, the sample from $X$ did not come from the missing person, and therefore the genotype of $X$ does not depend on the genotypes of $P$ and $Q$ and the genotype of $C$ does not depend on the genotype of $X$.

The likelihood ratio is arranged to involve probabilities of genotypes conditional on previous generations. If both parents of an individual have been typed, there is no need to condition on the grandparents of that individual.

In the following slides, $C, S, X, P$ and $Q$ represent the genotypes of the child, the remains, the spouse and the parents of the missing person.

# Exercise 3b: Missing Persons

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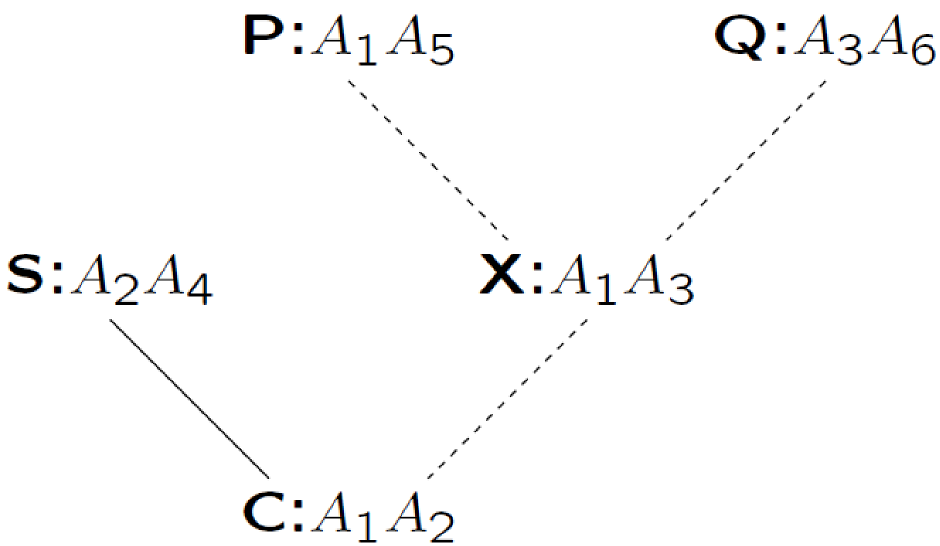
In the following slides, $C, S, X, P$ and $Q$ represent the genotypes of the child, the remains, the spouse and the parents of the missing person.

# Exercise 3b: Missing Persons

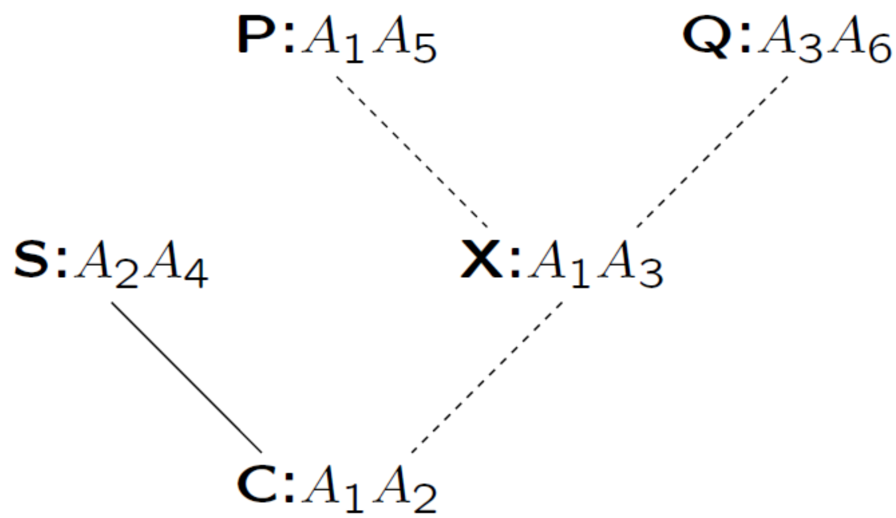
$$\begin{aligned}
\text{LR} &= \frac{\text{Pr}(E|H_p)}{\text{Pr}(E|H_d)} \\
&= \frac{\text{Pr}(C, S, X, P, Q|H_p)}{\text{Pr}(C, S, P, X, Q|H_d)} \\
&= \frac{\text{Pr}(C|S, X, P, Q, H_p)\,\text{Pr}(S, X, P, Q|H_p)}{\text{Pr}(C|S, X, P, Q, H_d)\,\text{Pr}(S, X, P, Q|H_d)} \\
&= \frac{\text{Pr}(C|S, X, H_p)\,\text{Pr}(S, X|P, Q, H_p)\,\text{Pr}(P, Q|H_p)}{\text{Pr}(C|S, P, Q, H_d)\,\text{Pr}(S, X|P, Q, H_d)\,\text{Pr}(P, Q|H_p)} \\
&= \frac{\text{Pr}(C|S, X, H_p)\,\text{Pr}(S|H_p)\,\text{Pr}(X|P, Q, H_p)}{\text{Pr}(C|S, P, Q, H_d)\,\text{Pr}(S|H_d)\,\text{Pr}(X|H_d)} \\
&= \frac{\text{Pr}(C|S, X, H_p)\,\text{Pr}(X|P, Q, H_p)}{\text{Pr}(C|S, P, Q, H_d)\,\text{Pr}(X|H_d)}
\end{aligned}$$

# Exercise 3b: Missing Persons




$$\text{LR} = \frac{\Pr(C|S, X, H_p)\,\Pr(X|P, Q, H_p)}{\Pr(C|S, P, Q, H_d)\,\Pr(X|H_d)}$$

# Exercise 3b: Missing Persons




$$
\begin{aligned}
\text{Pr}(C|S,X,H_p) &= 1/4 \\
\text{Pr}(X|P,Q,H_p) &= 1/4 \\
\text{Pr}(C|S,P,Q,H_d) &= 1/8 \\
\text{Pr}(X|H_d) &= 2p_1p_3 \\
\text{LR} &= \frac{1}{4p_1p_3}
\end{aligned}
$$