Calculating the Probability of Paternity

Objective: You will be able to interpret the results of a paternity test and calculate the Probability of Paternity or the chance that a father is the true parent of a child.

Introduction:
During a paternity test, a DNA profile is generated from samples collected from the mother, the child and one or more suspected fathers. The outcome of a paternity analysis can be one of the following:

1. The results indicate that the alleged father is not the biological father of the child. This conclusion is based on the absence of two or more alleles found in the child that were not donated by the father.
2. The results indicate that the alleged father cannot be excluded as the biological father of the child. This result is based on statistics calculated for the comparison. Even so, it is not correct to say “you are the father” because that implies 100% probability. Therefore, the results are reported as “the alleged father cannot be excluded as the biological father of the child”.
3. The statistical results derived from the genetic tests fall within the inconclusive range for paternity. This result usually takes place when the sample from the mother is missing or some other difficulty occurred during the analysis.

Source of information http://www.paternitytestindia.com/understand_paternity_results.php

Directions: The following STR are from a woman (M) who was involved with three different men and who concieved a child by one of them. She is interested in determining the true paternity of the child. The following are the results of the analysis from the child (C), mother (M), and three possible fathers (F1, F2, and F3). All individuals are Caucasian.

<table>
<thead>
<tr>
<th>Loci</th>
<th>C</th>
<th>M</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
</tr>
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<tr>
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</table>

In order to determine who the father might be, look for the obligate paternal allele. It is the allele that the father must donate to the child (the other allele is donated by the mother). For example, the mother donated the 10 repeat for the CSF1PO STR. All three alleged father’s had the ability to donate the obligate paternal allele, the 12 repeat to the child. All three fathers are suspect based on this STR.
Explain how you know which alleged father cannot be excluded as the father of the child? Use the term “obligate paternal allele” in your answer.

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The rule for eliminating the other suspected fathers is if two or more obligate paternal alleles are not donated by the suspected father, they are excluded as a match. F2 was omitted at 5 STR genotypes and F3 was omitted at 6 STR genotypes. The probability that F1 cannot be excluded as the father must be calculated for his paternity to be considered valid in court.

Calculating a Paternity Index:

Most courts require that the “Probability of Paternity,” a measure of how accurate the test results are, be at least 99%. That means there is a 99% chance that the alleged father is truly the father of the child in question and that a random man chosen from the population has only a 1% chance of being the father.

To calculate the “Probability of Paternity,” a “Paternity Index” must be calculated for each STR. The Paternity Index (PI) is a ratio which, given the mother’s genotype, compares the likelihood that the alleged father could produce said child to the likelihood that a randomly chosen man from the alleged father’s race could do so. The formula is as follows:

\[ \text{PI} = \frac{\text{Probability (Alleged father contributed the obligate allele)}}{\text{Probability (Random male contributed correct allele)}} \]

Consider the CSF1PO STR. The mother contributed the 10 repeat and the father contributed the 12 repeat. The probability that the alleged father contributed the obligate allele is considered .5 or 50% because he was heterozygous for the allele and had a 50% chance of contributing the 11 allele! The probability that a random male Caucasian contributed the allele is 0.361 (as per Butler et al.).

The PI is then, \( 0.5 / 0.361 = 1.385 \).

Next, consider the D3 STR. The obligate paternal allele was the 16 repeat. F1 was homozygous for the 16 repeat. In this case, the father had a 100% chance of contributing the obligate paternal allele.

The PI is then, \( 1 / .253 = 3.95 \).

A Combined Paternity Index is then calculated as the product of all PI’s:

\[ \text{(PI CSF1PO) (PI FGA) (PI THO1)} \]

Practice this calculation on the next page!
Complete the following chart to determine the Combined Paternity Index:

<table>
<thead>
<tr>
<th>Loci</th>
<th>C</th>
<th>M</th>
<th>F1</th>
<th>PI</th>
</tr>
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<tr>
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<td>16,16</td>
<td>16,17</td>
<td>16,16</td>
<td>1 / (        ) =</td>
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<tr>
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<td>12,12</td>
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<tr>
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<td>28,29</td>
<td></td>
</tr>
</tbody>
</table>

Combined Paternity Index (CPI)

Calculating the Probability of Paternity:

Once you have calculated the Combined Paternity Index, you can determine the Probability of Paternity. Typically, courts will require that the Probability of Paternity be calculated. Many states mandate that this probability be at least 99% or greater.

The Probability of Paternity is determined by the following equation:

\[ \text{Prob(Paternity)} = \frac{\text{CPI}}{\text{CPI} + 1} \]

Calculate the Probability of Paternity for the situation above. Show your work:

Probability of Paternity (multiply by 100)________________________
Questions:
1) Refer to the introduction and describe the results of the paternity test you just finished. Make sure you use the statements, “obligate paternal alleles” and “cannot be excluded…”

2) Two important points to remember are that the higher the Paternity Index, the less likely further testing would produce an exclusion. Paternity Index estimates are only as good as the databases used to produce them. Calculate the Paternity Index for the following frequencies (assume the father has only one copy of the obligate allele (he was heterozygous):
   a. 0.025 __________
   b. 0.075 __________
   c. 0.100 __________
   d. 0.200 __________
   e. What trend do you see in the PI given the frequency of the allele?

3) Calculate the Probability of Paternity for the following Paternity Indexes:
   a. 10 ______________
   b. 100 ______________
   c. 1000 ______________
   d. 10000 ______________
   e. What trend do you see in the Probability of Paternity given the PI?
Example of Paternity Results from an Electrophoresis Gel testing one STR:

4 The bands below are from 8 different STR loci. They are separated for ease of identification. Look at the location of each band to determine if the repeats are the same. Try to determining if any of the alleged fathers is the parent of the child. For each STR loci, the child’s DNA should contain one band from the mother and one from the father.

<table>
<thead>
<tr>
<th>loci</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<td>II</td>
<td>II</td>
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</tbody>
</table>

Who is the likely father? Explain in detail. Include why the other alleged fathers were excluded from being the child’s parent.

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