Épreuve de section européenne

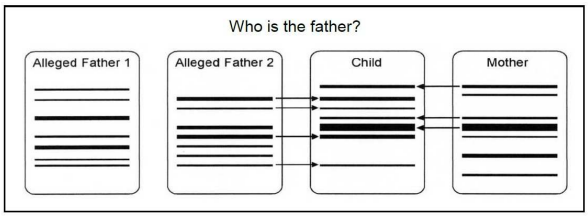
Genetic fingerprinting

Genetic (or DNA) fingerprinting was developed by Professor Sir Alec Jeffreys at the University of Leicester in 1984. The technique is based on the fact that each of us has a unique sequence or code of genetic information, contained in our DNA (deoxyribonucleic acid). This is inherited from our biological parents, half from our mother and half from our father.

Although the majority of DNA doesn't differ from human to human, about 0.10 percent of a person's entire genome varies from person to person. These areas of DNA, called minisatellites (short sequences of chemical building blocks) show variation in the numbers of repeat units unique to each person. These form the bands that are illustrated below. Experimental evidence has shown that amongst unrelated people, the probability of one given band matching with another is one in four; however, this probability of 0.25 has been the subject of recent debate in court cases.

DNA information can be recovered from human and animal remains as far back as Neanderthal man and has been used to solve a number of high profile mysteries from the past.

Apart from identification, paternity and immigration cases, the technique is also used in medical research. It is usual to compare between 10 and 20 bands. Unless you have an identical twin, your DNA is unique to you, this is what makes DNA evidence so valuable in investigations – it's almost impossible for someone else to have DNA that is identical to yours. The sketch below shows, in simplified form, how genetic fingerprinting can be used to identify a child's father.



Alleged father 2 has 4 matching bands with the child

From CIMT, University of Plymouth website

Questions

1. What are the mathematical fields used in genetic fingerprinting?
2. How was the probability $p = \frac{1}{4}$ of having one given band in common estimated?
3. (a) Assuming that you compare each band independently from one another, check that the probability of matching 2 out of 2 bands being compared is $\frac{1}{16}$.
   (b) Is it sufficient to compare two bands to distinguish people?
4. Find the probability of:
   (a) 10 bands out of 10 matching;
   (b) 20 bands out of 20 matching.
5. (a) Find the lowest integer n such that $\left(\frac{1}{4}\right)^n < \frac{1}{60000000}$. Let us denote this value n_0.
   (b) The population of the UK is about 60 million. Comment on the following statement: "n_0 is the number of bands that need to be compared in the UK to ensure that it is safe to convict someone on DNA evidence alone, that is, for a full match of the n_0 bands not happening by chance".