PROBABILITY AND THE LAW

MARCELLO DI BELLO – STANFORD UNIVERSITY

HANDOUT #3 – JAN 24, 2014

0. AMAZING COINCIDENCES

U.S. v. John Veysey (2003)

> John Veysey appeals from his conviction, after a jury trial, and sentence of 110 years in prison for mail and wire fraud, arson, and the related offense of felony by fire. The facts are amazing, but we shall resist the temptation to recount them at length. In 1991 Veysey set fire to his house and inflated the claim that he then filed with his insurer. The insurer paid, and the house was rebuilt. The following year Veysey married a woman named Kemp, increased the insurance on the house, removed the valuable contents of the house, along with himself and his wife, and then cut the natural-gas line inside the house, causing the house to fill up with gas and explode spectacularly, utterly destroying it. He grossly exaggerated the value of the property allegedly lost in the explosion—some did not exist and some he had removed before the explosion. The insurance company (a different one) paid, and he used part of the proceeds to buy another house. The next year he tried to kill his wife by driving his van with her in it into a river. When that failed he killed her by poisoning her, and collected $ 200,000 in the proceeds of insurance policies on her life. He placed personal ads in newspapers, seeking to meet women. He became engaged to one of the women he met through his ads, named Donner, but broke his engagement after failing to procure a $1 million policy on her life. He then took up with a Ms. Beetle. This was in 1996 and the same year he burned down his house, again submitting an inflated estimate of the loss and receiving substantial proceeds from the insurance company (a different one, again). He then married Beetle, and they moved into a rented house. She insured her life for $ 500,000 with him as beneficiary. One night in 1998, after drugging her, he set fire to the house, hoping to kill both her and their infant son, on whom he had also taken out a life insurance policy and who was in the house with her. They were rescued, and soon afterwards Veysey and Beetle divorced. The house was rebuilt and Veysey persuaded a woman named Hilkin to move in with him after she had accumulated some $ 700,000 in life insurance and named him as the primary beneficiary. He apparently intended to murder her, but he was arrested before his plans matured. There is more, but these are the highlights.

1. BAYES' THEOREM

Recall that confusing $P(A|B)$ and $P(B|A)$ is known as the *inversion fallacy* or *prosecutor fallacy*. Bayes' theorem shows how the two probabilities are related, as follows:

$$P(A|B) = \frac{P(B|A)}{P(B)}P(A) = \frac{P(B|A)}{P(B|A)P(A) + P(B|\neg A)P(\neg A)}P(A).$$

Bayes' theorem allows us to calculate the *conditional* probability of A given B from:
(i) the probability $P(A)$ regardless of B;
(ii) the probability $P(B)$, where $P(B) = P(B|A)P(A) + P(B|\neg A)P(\neg A)$;
(iii) the *likelihood* $P(B|A)$, i.e. the probability of B given A.

2. COLLINS AND BAYES' THEOREM

Let us stipulate that
(a) the guilty couple, in fact, fits the description D (blond, ponytail, mustache, etc.);
(b) the Collins match description D; and
(c) D has a frequency of 1 in 12,000,000.
Let M stand for *the Collins match the description D* and let G stand for *the Collins are guilty*.
Bayes' theorem tells us that

$$P(G|M) = \frac{P(M|G)}{P(M)}P(G) = \frac{P(M|G)}{P(M|G)P(G) + P(M|\neg G)P(\neg G)}P(G).$$

We can assume—simplifying a bit!—that
$P(G) = \frac{1}{n}$, with n the population of, say, Los Angeles and vicinities (maybe 6 million people?);
$P(M|G) = 1$; and
$P(M|\neg G) = \frac{1}{12{,}000{,}000}$.

So we have

$$P(G|M) = \frac{1}{\frac{1}{n} + \frac{1}{12{,}000{,}000} \times \frac{n-1}{n}} \times \frac{1}{n} = \frac{1}{1 + \frac{1}{12{,}000{,}000} \times (n-1)}.$$

With $n = 6,000,000$, we get

$$P(G|M) \approx \frac{1}{1 + \frac{1}{2}} = \frac{1}{\frac{3}{2}} = \frac{2}{3}.$$

3. DNA EVIDENCE BASICS

DNA evidence consists of two or three pieces of information:
(1) match between an individual's DNA profile and DNA profile associated with crime traces;
(2) estimate of the DNA profile's frequency (also known as *Random Match Probability*);
(3) background information (e.g. shape, conditions, arrangement, location of the traces).

DNA evidence is used in criminal cases (e.g. rape) and civil cases (e.g. disputed paternity).

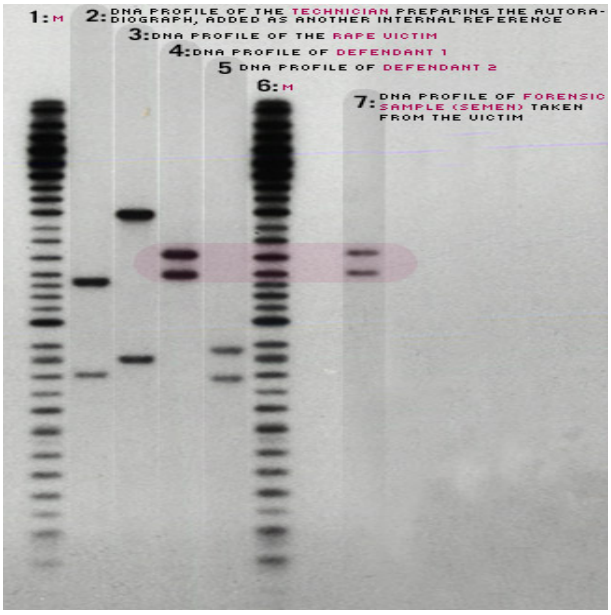
4. WHAT CAN DNA EVIDENCE ESTABLISH?

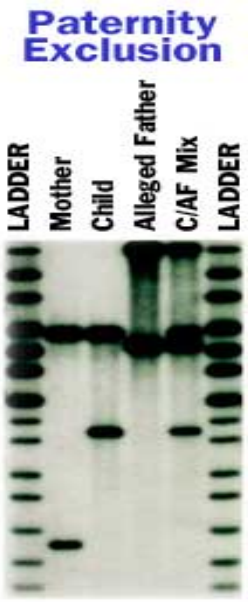
Do not conflate *source*, *presence*, and *guilt*. Keep in mind the following inferential chain:

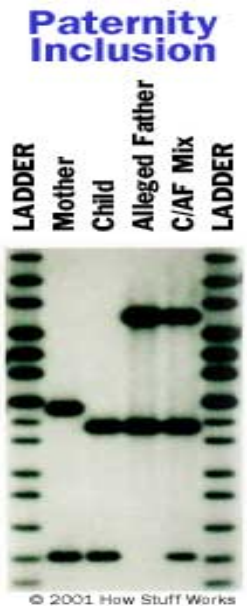
declared match → factual match → source → presence → involvement → actus reus → guilt

QUESTION: Can DNA evidence **alone** establish guilt? Can it establish source?

5. DECLARING A MATCH







Usually, a **tolerance window** is used within which a match is declared [qualitative dichotomous statement]. *Alternatively*, we can use **degrees of congruence** [quantitative statement].

QUESTION: Which one of the two approaches is better?