Pitchfork

The Case

On 21 November 1983, a 15-year-old girl named Lynda Mann left her home to visit a friend's house. She did not return. The next morning she was found raped and strangled on a deserted footpath known locally as the Black Pad. Using forensic science techniques available at the time, police linked a semen sample taken from her body to a person with type A blood and an enzyme profile that matched only 10 percent of males. With no other leads or evidence, the case was left open.

On 31 July 1986, another 15-year-old girl, Dawn Ashworth, took a shortcut instead of taking her normal route home. Two days later, her body was found in a wooded area near a footpath called Ten Pound Lane. She had been beaten, savagely raped and strangled to death. The modus operandi matched that of the first attack, and semen samples revealed the same blood type.

The Suspect

The prime suspect was Richard Buckland, a local 17-year-old youth with learning difficulties, who revealed knowledge of Ashworth's body, and admitted the crime under questioning, but denied the first murder. Alec Jeffreys, of the University of Leicester, had recently developed DNA profiling along with Peter Gill and Dave Werrett of the Forensic Science Service (FSS) and detailed the technique in a 1985 paper.

Using this technique, Jeffreys compared semen samples from both murders against a blood sample from Buckland which conclusively proved that both girls were killed by the same man, but not Buckland. The police then contacted the FSS to verify Jeffreys' results and decide which direction to take the investigation. Buckland became the first person to have his innocence established by DNA fingerprinting.

"The Blooding"

Leicestershire Constabulary and the FSS then undertook an investigation in which 5,000 local men were asked to volunteer blood or saliva samples. This took six months, and no matches were found.

On 1 August 1987, Ian Kelly, one of Pitchfork's colleagues at the bakery, revealed to fellow workers in a Leicester pub that he had obtained 200 British pounds for giving a sample while masquerading as Pitchfork. Pitchfork told Kelly that he could not give blood under his own name because he had already given blood while pretending to be a friend of his who had wanted to avoid being harassed by police because of a youthful conviction for burglary. A woman who overheard the conversation reported it to police. On 19 September 1987 Pitchfork was arrested at his home in Haybarn Close, in the neighbouring village of Littlethorpe and a sample was found to match that of the killer.

"The Blooding"

During subsequent questioning, Pitchfork admitted to flashing females over 1,000 times, a compulsion that he had started in his early teens. Flashing led to sexual assault and then to strangling his victims in order to protect his identity. He pleaded guilty to the two rape/murders in addition to another incident of sexual assault that he had committed.

He was sentenced to life imprisonment and concurrent terms for rape and murder. The Secretary of State set the tariff or minimum term before consideration could be given to his possible release at 30 years, which was reduced on appeal by 2 years, to 28 years. Parole was denied in 2016.

Initial Genetic Typing

ABO blood groups: three alleles A, B, O give six genotypes AA, AO, BB, BO, AB, OO and four blood groups A, B, AB, O. Blood group A has A-antigens on the red cells and ant-B antibodies in the serum. It becomes agglutinated by anti-A serum. Blood group A is the most common type in people of European ancestry, with a frequency of around 40% in England.

About 70% of blood group A people are secretors: they secrete ABO antigens in saliva, semen and other fluids.

Another blood type classification is provided by the PGM enzyme. About 40% of European-ancestry people living in England have PGM type 1+.

Initial Genetic Typing

Semen was detected on a vaginal swab from victim Lynda Mann. "Given a phosphoglucomutase (PGM) grouping test, the semen showed PGM 1+ enzyme reaction. It was antigen-tested and found to contain strong amounts of Group A secretor substance." (Wambaugh, p 41).

If ABO type, secretor status and PGM types were all independent, and if the frequencies published by Rothwell (1985) were appropriate, then the probability of a man being Group A secretor, PGM 1+ would be $0.40 \times 0.70 \times 0.40 = 0.11$ or close to 1 in 10. This typing system is better for excluding men than for identifying a specific man.

DNA Fingerprinting

Jeffreys (1985) introduced the idea of using minisatellites for human identification.

Jeffreys cut the DNA in a sample into many fragments with a restriction enzyme then probed this mixture with a probe consisting of the repeat unit for a minisatellite. The probe 33.15 detects about 15 fragments per individual, and these fragments varied in length according to how many repeat units they carried. When the fragments from different people were compared they were found to be quite different, and the fragment patterns for related people showed the amount of fragment sharing expected if the minisatellites obeyed Mendel's laws.

DNA Fingerprinting

To estimate how discriminating minisatellites are, Jeffreys (Nature 316:76-79, 1985) reported results from typing 20 unrelated British Caucasians. The DNA fragment patterns were compared between each pair of people. The proportion of times a probe 33.15 band found for one person was also found for the other person were:

Fragment size	Proportion
10-20 kb	0.08
6-10 kb	0.20
4-6 kb	0.27

Led to a prediction that the probability of the 33.15-profile for one individual being the same as that of another individual is 3×10^{-11}.

DNA Fingerprinting Calculations

Jeffreys gave some calculations for the chance of two people having the same "DNA fingerprint" by chance. Those calculations are no longer used.

Jeffreys' methods were later described as using multilocus probes. Nothing was known about the genomic locations of these 15 minisatellites, and the number of bands seen for each probe wasn't known in advance. Subsequently, forensic scientists uses single locus probes that identified two fragments at a known location in the genome – there were still problems with interpretation as will be discussed in the Castro case example.

Castro

The Case

From Mnookin (2007): "Looking back on People v. Castro, there is no particular mystery about what happened. There is no reason to doubt that the defendant, Joseph Castro, a handyman, did in fact commit the murders with which he was charged, the fatal stabbings of Vilma Ponce and her two-year-old daughter. In fact, in People v. Castro, there was no trial, for the defendant ended up pleading guilty to second degree murder before the trial began. The case we now call People v. Castro was nothing more than a preliminary hearing about the admissibility of evidence at trial. Nor did People v. Castro lead to any change in legal rules or to a formal, explicit shift in any evidentiary doctrine.

The Case

A young man returned to the Bronx apartment he shared with his common-law wife, 20-year-old Vilma Ponce, late in the afternoon on February 5, 1987. He unlocked both of the two locks on the door, but could not enter because the chain locking the door was attached from the inside. He called out the name of his wife and daughter, but was answered only by silence. Concerned and somewhat anxious, he attempted to phone his wife, thinking that perhaps she was sleeping. When no one answered, he called his mother, who lived nearby, to see if she had any possible explanation, but she hadn't spoken to his wife since earlier that afternoon. Growing increasingly concerned, he asked his mother to call the police. He stood outside his building, and attempted to whistle up to his apartment, thinking that maybe his wife or daughter would hear him. Just then he saw a ghastly sight: a man leaving the building, his face, arms and shoes smeared with blood.

The Case

Moments later, the police arrived. When they entered the apartment, they discovered that Ponce, six months pregnant at the time, and Natasha, the couples two-year-old daughter, both lay dead, victims of a brutal stabbing. Ponce, found nude from the waist down, had been perforated nearly 60 times, and her small daughters body had been stabbed at least 16 times. While the victims boyfriend initially failed to pick Castro out of an array of photographs, he subsequently identified Joseph Castro as the man he saw leaving the building with bloody hands that afternoon. Castro lived nearby, and did odd jobs in various buildings in the neighborhood, including, on occasion, Vilma Ponce's.

The Case

Police investigation found further evidence to buttress the eyewitness identification of Castro and to support a circumstantial case that Castro was indeed the murderer. According to one of Vilma Ponces friends, Ponce had pointed Castro out to her on the street just a week before the murder, complaining that he frequently made suggestive remarks to her. Her friend told her to tell her husband, but Ponce said she didn't want to provoke a possibly violent confrontation between the two men. The police found that one of the locks on Ponce and Rivera's door was improperly installed, and therefore didn't workand they discovered that Joseph Castro himself, assisting the building superintendents nephew, had helped to install the malfunctioning lock just two weeks earlier. In addition, because the police found Ponce's just-bought groceries, including meat and chicken, still sitting in a bag on the living room sofa rather than in the refrigerator, they speculated that Ponce had been surprised by her attacker just after getting homeperhaps before she had a chance to latch the second, actually- functioning lock on her door.

The Case

All of this was suggestive: it provided the outlines for a story that fingered Castro as a possible suspect and gave tantalizing hints of both motive and opportunity. But the police still might not have had a persuasive case had they not, when they questioned Castro, seized a watch he was wearing, stained with what looked like dried blood. If it was blood and if it could be persuasively linked to Vilma or Natasha, that would transform a circumstantial case into a slam-dunk story of Castro's guilt."

Frye Hearing

From Mnookin (2007): "Judge Sheindlin explained in his ruling that he would be guided by a three-prong test for examining whether the prosecution's DNA evidence met the Frye standard of general acceptance:

- Prong I. Is there a theory, which is generally accepted in the scientific community, which supports the conclusion that DNA forensic testing can produce reliable results?

- Prong II. Are there techniques or experiments that currently exist that are capable of producing reliable results in DNA identification and which are generally accepted in the scientific community?

- Prong III. Did the testing laboratory perform the accepted scientific techniques in analyzing the forensic sample in this particular case?17

He concluded "yes" to prongs 1 and 2, but "no" to prong 3. The DNA evidence was not admitted.

Lander's Criticism

- 1. "With due respect, the courts have been too hasty. Although DNA fingerprinting clearly offers tremendous potential as a forensic tool, the rush to court has obscured two critical points: first, DNA fingerprinting is far more technically demanding than DNA diagnostics; and second, the scientific community has not yet agreed on standards that ensure the reliability of the evidence. DNA fingerprinting, by contrast, is more like analytical biochemistry: one must determine whether two completely unknown samples are identical. Because hypervariable RFLP loci often involve 50–100 alleles yielding restriction fragments of very similar lengths, reliably recognizing a match is technically demanding. At one commonly used locus, for example, most alleles lie within a mere 2 per cent of the length of the gel."

- 2. "For example, it is assumed without convincing proof that Caucasians, Blacks and Hispanics can each be regarded as homogeneously mixed populations, without significant subgroups, even when considering loci at which most alleles are relatively young from the perspectives of population genetics. Yet despite such fundamental uncertainties, forensic laboratories blithely cite breathtaking frequencies: a recent report based on the study of only four RFLPs announced that the chance of an alleged match occurring at random was 1 in 738,000,000,000,000."

Lander's Criticism

- 3. "Why then was a match declared? Lifecodes stated that it did not actually use the objective threshold of 3 s.d.s. for declaring a forensic match: its decisions were based on subjective visual comparison. Agreeing that the explicit statements in the forensic report implied that the objective criterion had been used, Baird allowed that the statement 'may not be the best explanation' of the company's actual procedures."

- 4. "To justify applying the classical formulas of population genetics in the Castro case, the Hispanic population must be in Hardy-Weinberg equilibrium. In fact, Lifecodes' own data show that it is not. The classical test for Hardy-Weinberg equilibrium is based on Wahlund's principle that the rate of homozygosity in a population containing distinct subgroups will be higher than would be expected under the assumption of random mating. Applying this test to the Hispanic sample, one finds spectacular deviations from Hardy-Weinberg equilibrium: 17 per cent observed homozygotes at D2S44 and 13 per cent observed homozygotes at D17S79 compared with only 4 per cent expected at each locus, indicating, perhaps not surprisingly, the presence of genetically distinct subgroups within the Hispanic sample."

Lander's Criticism

- 5. "An appropriate start would be a US National Academy of Sciences committee, charged with preparing a report on guidelines for DNA fingerprinting. There is ample precedent: when voiceprint evidence began to be introduced in the 1970s, the academy convened such a group to examine the technology. An academy study on DNA fingerprinting had been planned for last year, but was postponed indefinitely when the National Institute of Justice would not finance it. As one justice official told me, the study was unwelcome: scientists had done their part by discovering DNA; it was not their job to tell forensic labs how to use it."

Response to Lander

Lander's first three points are well taken. His fifth point may have led to his appointment to a National Academy of Sciences report on DNA typing issued in 1992. It was so widely criticized that a second report was issued in 1996. It is the fourth point, on Hardy-Weinberg equilibrium (HWE) that we consider in some depth.

Johnson

The Case

Victim alleged rape by two men.

DNA profiles of vaginal swab and of suspect Kelvin Johnson were determined by California Department of Justice laboratory.

The swab profile indicated a mixture of DNA from (at least) two people.

Three aspects of this case

- Need alternative explanations for the evidence, and calculation of likelihood ratio.

- Account for the evidence being a DNA mixture.

- Account for relationship between alleged perpetrators.

The Evidence

Locus	Swab	K. Johnson
D1S7	a:8773 b:7760 c:4016	a:8839 b:7770
D2S44	a:1802 b:1214 c:1648	a:1804 b:1214
D4S139	a:6642 b:4168 c:6090 d:3471	a:6654 b:4211
D5S110	a:2079 b:1367 c:5272	a:2086 b:1373
D10S28	a:3716 b:1582 c:2151	a:3747 b:1586
D17S79	a:2023 b:1804 c:1861	a:2023 b:1789

Kelvin Johnson not excluded as a contributor to the swab profile.

Interpretation of Evidence

One possible pair of explanations H for the evidence E (the swab profile):

- H_p : Kelvin Johnson and an unknown man were the contributors to the swab profile. What is Pr$(E|H_p)$?

- H_d: Two unknown men were the contributors to the swab profile. What is Pr$(E|H_d)$?

Need to determine which alleles must have come from the unknown man under each explanation.

Alleles from unknown man under H_p

Identify the allele(s) that the unknown man must carry.

Locus	Swab	K. Johnson	Unknown
D1S7	a,b,c	a,b	c
D2S44	a,b,c	a,b	c
D4S139	a,b,c,d	a,b	c,d
D5S110	a,b,c	a,b	c
D10S28	a,b,c	a,b	c
D17S79	a,b,c	a,b	c

Genotypes of unknown man under H_p

Identify the possible genotypes of the unknown man.

Locus	Swab	Unknown man Alleles	Unknown man Genotypes
D1S7	a,b,c	c	ac, bc, cc
D2S44	a,b,c	c	ac, bc, cc
D4S139	a,b,c,d	c,d	cd
D5S110	a,b,c	c	ac, bc, cc
D10S28	a,b,c	c	ac, bc, cc
D17S79	a,b,c	c	ac, bc, cc

Genotypes of unknown men under H_d

Identify the possible genotypes of the unknown men.

Alleles	Genotypes
a,b,c	aa,bc: bb,ac: cc,ab: ab,ac: ab,bc: ac,bc
a,b,c,d	ab,cd: ac,bd : ad,bc

Possibility of Relatives

The fact that five of the six loci had only three alleles suggests allele-sharing by two contributors. This, in turn, suggests relatives.

Search of California offender database for relatives of Kelvin Johnson found his half-brother George.

Complete Set of Profiles

Locus	Swab	Kelvin	George
D1S7	a	a	a
	b	b	
	c		c
D2S44	a	a	a
	b	b	
	c		c
D4S139	a	a	
	b	b	
	c		c
	d		d
D5S110	a	a	a
	b	b	
	c		c
D10S28	a	a	a
	b	b	
	c		c
D17S79	a	a	a
	b	b	
	c		c

Interpretation of Evidence

There are now several possible explanations:

- George and Kelvin were the contributors.
- George and an unknown man were the contributors.
- Kelvin and an unknown man were the contributors.
- Two unknown but related men were the contributors.
- Two unknown and unrelated men were the contributors.

Hypotheses

The prosecutor believed that George and Kelvin were the contributors. The defense did not offer an alternative set of contributors.
Pairs of explanations that assumed Kelvin either was or was not a contributor:

H_p: George and Kelvin were the contributors.
H_d: George and an unknown man were the contributors.
or
H_p: George and Kelvin were the contributors.
H_d: Two unknown and related men were the contributors.
or
H_p: George and Kelvin were the contributors.
H_d: Two unknown and unrelated men were the contributors.

Hypotheses

For each of these pairs of explanations, the swab profile has probability of 1 under the prosecution's explanation H_p. It is necessary to determine the probability of the profile under each of the three alternative explanations. We have already found the probabilities under the last alternative.

It is conservative, and therefore favorable to the defense, to assume there were only two contributors to the sample. A larger number of contributors leads to a lower probability of the sample profile, because it is less likely that more than two people have only three or four alleles per locus between them.

What about my other brother George?

At the DNA admissibility hearing, the defense pointed out that Kelvin has another brother George. This man is Kelvin's full brother.
Other pairs of explanations for the swab profile can therefore be considered:

P_2: Kelvin and half-brother George were the contributors.
D_5: Half-brother George and another brother (George) were the contributors.
or
P_2: Kelvin and half-brother George were the contributors.
D_6: An unknown person and another brother (George) were the contributors.

Franklin

The Case

"Franklin killed between 1985 and 2007 and earned the moniker "The Grim Sleeper" because of an apparent fourteen-year hiatus from murder in the middle of this period. Traditional police methods, including a $500,000 reward and at one point as many as thirty detectives, failed to apprehend the fifty-seven-year-old, retired police mechanic who dumped at least twelve bodies in alleys near downtown Los Angeles. When traditional forensic methods failed, investigators turned to novel partial-match DNA search methods authorized in 2008 by then California Attorney General, Jerry Brown. Investigators linked Franklin to more than a dozen Los Angeles County homicides after their partial-match DNA search produced a positive result, not to Franklin, but to the DNA of Franklin's son, who had recently been incarcerated.

The Case (Contd.)

A partial-match DNA search produces results by making less-than-perfect identifications in DNA databases to persons who may or may not have a familial connection to the source DNA. Franklin was arrested in July 2010 after police investigators matched crime scene DNA to DNA that police retrieved from a piece of pizza that Franklin had discarded. The "closely guarded" procedures the state used between the discovery of the partial match to Franklin's son and Franklin's eventual arrest sparked immediate, if restrained, controversy."

Barca, 2013.

The trial of Franklin began in February of 2016.

Familial Searching: FBI website

"Familial searching is an additional search of a law enforcement DNA database conducted after a routine search has been completed and no profile matches are identified during the process. Unlike a routine database search which may spontaneously yield partial match profiles, familial searching is a deliberate search of a DNA database conducted for the intended purpose of potentially identifying close biological relatives to the unknown forensic profile obtained from crime scene evidence. Familial searching is based on the concept that first-order relatives, such as siblings or parent/child relationships, will have more genetic data in common than unrelated individuals. Practically speaking, familial searching would only be performed if the comparison of the forensic DNA profile with the known offender/arrestee DNA profiles has not identified any matches to any of the offenders/arrestees.

FBI website (Contd.)

Familial searching is often confused with what occurs when a partial match results from the routine search of the DNA database. A partial match is the spontaneous product of a regular database search where a candidate offender profile is identified as not being identical to the forensic profile but because of a similarity in the number of alleles shared between the two profiles, the offender may be a close biological relative of the source of the forensic profile."

The distinction made here may reflect some states not allowing familial searching, yet putative relatives may be revealed by a "regular database search."

Familial Searching: Basic calculations

DNA profiles of relatives are expected to be more similar than profiles of unrelated people. The basic calculations rest on the probabilities that two people have particular profiles.

For unrelated people:

$$\Pr(\text{Match}) = 0.02, \Pr(\text{Partial Match}) = 0.32, \Pr(\text{Mismatch}) = 0.66$$

and full-siblings:

$$\Pr(\text{Match}) = 0.3, \Pr(\text{Partial Match}) = 0.5, \Pr(\text{Mismatch}) = 0.2$$

and for parent-offspring:

$$\Pr(\text{Match}) = 0.1, \Pr(\text{Partial Match}) = 0.9, \Pr(\text{Mismatch}) = 0.0$$

Basic calculations

For a single locus, a partial match supports relatedness over unrelatedness, but not hugely so:

$$\frac{\Pr(\text{Partial match}|\text{Parent}-\text{offspring})}{\Pr(\text{Partial match}|\text{Unrelated})} = \frac{0.9}{0.32} = 2.8$$

$$\frac{\Pr(\text{Partial match}|\text{Full}-\text{siblings})}{\Pr(\text{Partial match}|\text{Unrelated})} = \frac{0.5}{0.32} = 1.6$$

However, if 12 loci gave 3 matches, 6 partial matches and 3 mismatches, then

$$\frac{\Pr(\text{Partial match}|\text{Parent}-\text{offspring})}{\Pr(\text{Partial match}|\text{Unrelated})} = 0$$

$$\begin{aligned}\frac{\Pr(\text{Partial match}|\text{Full}-\text{siblings})}{\Pr(\text{Partial match}|\text{Unrelated})} &= \left(\frac{0.3}{0.02}\right)^3\left(\frac{0.5}{0.32}\right)^6\left(\frac{0.2}{0.66}\right)^3 \\ &= 1,367\end{aligned}$$

Franklin Case Calculations

Details are not available for the Franklin case, but every one of 15 loci must have shown a full or partial match. The combined probability of a full or partial match is 1.0 for parent-offspring pairs and 0.34 for unrelated people. The likelihood ratio is, therefore,

$$\frac{\Pr(\text{Partial match}|\text{Parent}-\text{offspring})}{\Pr(\text{Partial match}|\text{Unrelated})} = \left(\frac{1.00}{0.34}\right)^{15} = 10,661,449$$

This degree of matching is 10 million times more likely if the evidence profiles were from the son or father of the person in the database than if they were from a man unrelated to the person in the database.

California

"In considering whether familial searching should be implemented in your jurisdiction, it is important to recognize that a relative must already be in the database in order for the search to identify them as a potential relative of the forensic profile. It should be noted that even if a relative is in the database, it is possible that the relative may not be included in the ranked list produced by the familial search. For example, California's validation of their familial searching protocol showed that approximately 93% of fathers and 61% of full siblings were identified by their familial search procedure using the CODIS 13 core loci in searching a database of approximately one million DNA profiles (96% of fathers and 72% of full siblings were identified using 15 loci). However, regardless of whether or not a relative is in the database, a familial search will always generate a ranked list of potential candidates for evaluation. "

FBI website.

California

"A Los Angeles serial murder/sexual assault case dubbed the Grim Sleeper, was one of the two subjected to familial searches twice, once in 2008 and again in 2010. No candidate offenders with matching Y-STR profiles were identified in the results of the first search. The second search yielded a Y-STR match to a new highly ranked offender, who entered the California SDIS in 2009. Having passed this first hurdle (i.e., a highly ranked offender having a Y-STR profile that matches the evidence), and following a review by the Familial Search Committee, representatives of the California DOJ Bureau of Investigation and Intelligence conducted a review of available records that could support or dispel the hypothesis that the database offender is related to the perpetrator. In accordance with written DOJ policies, the Familial Search Committee undertook a final review of the available information.

California

By unanimous Committee vote, the convicted offender's name was released to the Los Angeles Police Department. This information led to the analysis of DNA recovered from a piece of pizza and other materials discarded by the offender's father, Lonnie David Franklin.

This highlights the final safeguard in the familial searching process: once a suspect is identified, a comparison must still be made between his reference DNA profile and that of the original crime scene evidence.

California

Given the profile of the tested convicted offender, the conditional probability that this offender's untested father's profile would randomly match the perpetrator's profile was equivalent to the numerator of a parent-child autosomal likelihood ratio calculation. ... there was an exceedingly low expectation of observing a random match across the 15 autosomal loci. After an intensive investigation and the determination that the profile of Lonnie Franklin was identical to the Grim Sleeper evidence profile, Lonnie Franklin was arrested."

Myers et al. (2011)

Autosomal and Y Typing

What did the California Department of Justice actually do? The following is taken from email from Steve Myers:

1. First search with autosomal profiles. The evidence profile must have all 15 Identifiler loci. Calculate and rank LRs separately for parent-offspring and full-sib relationships. This produces a list of highest-ranked matches in each case.

2. Then consider Y-STR profiles. Currently, DOJ performs familial searching only on male evidence profiles, and only male offenders are examined. The evidence is required to have a full Y-filer profile prior to the search. For a highly-ranked autosomal match, DOJ then extracts some of their archived convicted offender buccal or blood stains to type up to the top 50 from each list, removing duplicates and females - with Y-filer and, if needed, additional autosomal loci. (SDIS profiles do not have Y-STR types.)

Autosomal and Y Typing

3. If everything looks good, the Bureau of Investigations will then perform an investigation of public and law enforcement databases. They never make contact with anyone. That's ultimately left up to the originating law enforcement agency.

4. If there is a single locus Y-STR discrepancy, DOJ will perform a calculation that allows for mutation in the LR numerator.

Haimes, 2006

Forensic scientists have had little experience with family and kinship studies.

Familial searching refers to genetic relationships, not social arrangements of families.

Refers to research on adoption, assisted fertilization and so forth.

Haimes, 2006

Potential problems:

1. violating privacy of person on database.

2. violating privacy of (maybe large) pool of possible relatives who would not otherwise be involved in an investigation.

3. reinforcing views of prevalence of criminality in some families.

4. revealing to relatives the presence of a family member on a database.

5. revealing previously unknown genetic link between individuals.

6. revealing absence of genetic link previously thought to hold.

7. indirect lifelong surveillance of citizens even if they have not been even suspected of a crime.

Haimes, 2006

What would be examples of these seven problems?

How large is the pool of potential relatives? Haimes gives examples of 70 and 7,000 (reduced to 150).

"Shoe Rapist"

"A rapist with a shoe obsession who attacked a string of women in the early 1980s was finally caught after detectives matched a DNA sample from his sister with evidence gathered at the time of the assaults.

The so-called Dearne Valley shoe rapist terrorized women in the Rotherham and Barnsley areas of South Yorkshire, dragging victims off the street and tying them up with pairs of tights before raping them. Afterwards he would take their shoes.

His identity remained a mystery until South Yorkshire police decided to reopen the case five years ago. As part of the investigation, DNA samples gathered at the time were compared with samples on the police database. More than 40 close matches were obtained and the third house police visited was that of the rapist's sister, whose sample had been taken when she was arrested for an unrelated matter."

http://www.theguardian.com/uk/2006/jul/18/ukcrime.samjones

Erin Murphy

“ ‘It’s hard not to celebrate when an alleged serial killer is caught, but getting carried away based on glamorous cases like this is a real mistake,’ says Erin Murphy of the University of California, Berkeley, School of Law.”

[Miller G. 2010. Science 329:262.]

Murphy, 2010

This Article argues flatly against familial search methods. ... In short, I argue that familial searches should be forbidden because they embody the very presumptions that our constitutional and evidentiary rules have long endeavored to counteract: guilt by association, racial discrimination, propensity, and even biological determinism. They are akin to adopting a policy to collect and store the DNA of otherwise database-ineligible persons, solely because they share a blood relation with a convicted person, while deliberately sheltering similarly situated individuals from similar genetic exposure. Such an approach is likely be an ineffective means of crime control-particularly when weighed against the costs done to society by such a strategy-and even if effective, contradicts the very principles of equality and liberty that law enforcement serves to uphold and defend.

Murphy, 2010

'Success of kinship searching depends most saliently on a close relative of the perpetrator actually being in the offender database. Studies clearly in dicate a strong probabilistic dependency between the chances of conviction of parents and their children, as well as among siblings. Consistent with these studies . . . 46% of jail inmates indicated that they had at least one close relative who had been incarcerated.' But this argument proves too much. First, even if it could be shown that relatives of convicted offenders are more likely to themselves have been convicted of an offense, then if anything that simply suggests that the offender databases are themselves a sufficient source for finding a perpetrator. After all, it will only be relatives of convicted offenders who have themselves not been convicted , or committed a database-qualifying offense, who are burdened by familial searches.

Murphy, 2010

In a much more pedestrian case, a man who volunteered his DNA sample in a dragnet conducted to find a rapist found himself later ensnared in a web of suspicion. Although the sample did not match in the rape case, it was not destroyed but was instead entered into the database. A "cold hit" linked the sample to a 1996 case, a man who volunteered his DNA sample in a dragnet conducted rape, and the man was arrested. He was eventually released when the victim came forward to exonerate him, explaining that she and the man had engaged in consensual sex just before a stranger had raped her. Imagine, however, if the victim had died in the attack, or had not been able to be found ten years after the offense, or if the liaison had been merely fleeting? Given that genetic evidence alone can serve as the basis of conviction, it is In a much more pedestrian easy to imagine that a grave injustice might have occurred.

Murphy, 2010

The offensiveness of familial searches is not always physical in kind: consider Richard Jewell (the wrongly identified Atlanta bomber) or Stephen Hatfill (the wrongly identified anthrax mailer) or the members of the Duke University lacrosse team (falsely accused of rape). The worst indignity of an investigation can be living under a cloud of suspicion; even mere suspicion, quickly dispelled, has the potential to disrupt a career, destroy a marriage, or ruin a life. And to the extent that the alternative may be to let some crime go unsolved, it should be balanced against the claim to freedom from such victimization possessed by innocent relatives in equal proportion to the innocent victims of crime. Both have moral claims to the interests of security and liberty, whether from the perpetrators of crime or from the state itself.

Murphy, 2010

In our society, families are largely social, not biological, constructs.105 Yet when investigators follow up on genetic familial searches by asking, "Do you have any children?" or "Who is your father?", they ask a biological, not social, question. Answering may call for the disclosure of the most intimate of information: abandoned parental bonds, adoptee relationships, children conceived through technology, even family secrets about paternal identity. A lead may feel torn between identifying relatives, potentially exposing them to intrusive investigation, and revealing a confidence that severs the perceived biological tie. Analysts assigning value to genetic relationships may inadvertently uncover facts that even the parties do not know. For instance, consider an offender informed of a partial match who is asked about and reports no known siblings or children-but later learns that the offense was ultimately attributed to the child of his old flame, or that of his father's long-time coworker. Biological ties can be complicated matters, sometimes deliberately so.

Murphy, 2010

Lastly, it should be added that the DNA databases are not entirely composed of convicted offenders. Many states now include arrestee profiles, for instance. Databases can also include individuals who either submitted DNA samples voluntarily (for instance, in a DNA dragnet or to exclude themselves in an investigation), or even as victims of crime. In one notable case, a familial search identified a source through his sibling, a victim who had submitted a sample in an unrelated case. Familial search methods threaten to erode the good will between such individuals, victims, voluntary cooperators, etc., and the state, as those persons may fear that cooperation with the government will expose their relatives or themselves to later suspicion or apprehension.

Murphy, 2010

But if it is hard to muster much empathy for the source who turns out to have perpetrated the offense, then imagine instead the source who did not. In many cases, a familial search may locate the source, but the source is not, in fact, the perpetrator of the crime. At times that may be obvious. Maybe the source has an explanation, such as innocent presence at the scene or a rock-solid alibi-as in the case of the woman identified by DNA evidence who later turned out to have been in jail in another state at the time of the crime. Maybe the source will be facially implausible as a perpetrator such as the case of the man whose DNA was found on a rape-murder victim, but who was four years old at the time of the offense. But it is also possible that, in a number of cases, identification of the source may start the investigation for corroborating evidence. And for innocent suspects without ironclad defenses, or those against whom charges are brought decades after the offense, that process raises the risks of overreliance and confirmation bias discussed above.

Murphy, 2010

Although such stories are powerful in that they represent the closing of long-unsolved cases, it is worth considering the harm done to the family unit if such investigations become routine. While little sympathy might rest with the father, perhaps greater concern might be mustered for the nineteen-year old, who through one youthful indiscretion caused horrifying embarrassment and suspicion to be cast on his uncles. Such searches burden the relationship between innocent relatives and the convicted offender, as relatives find themselves suspected of a crime they did not commit by virtue of nothing other than their biological connection. Indeed, such strain can occur even absent an actual match: the mere awareness by Good Sibling that Bad Sibling's conviction now leaves her susceptible to this kind of intrusion may itself generate tension. And, of course, in many cases, the story will not end with a conviction-the familial search will prove fruitless.

Murphy, 2010

The concerns related to race and ethnicity are manifold, but I will focus on three here. First, familial searches of convicted offender and arrestee databases exacerbate the actual and apparent disparities of the criminal justice system, in which people of color are disproportionately represented. Second, the dependence on racial categorization in interpreting DNA typing results transmits a biological determinism about race that is not supported by science and that risks formally inscribing within the justice system inaccurate biases under the legitimizing mantel of scientific truth. And lastly, this widespread acceptance of racial and ethnic categorization as a means of quantifying DNA results (say, allelic frequencies) opens the door to a kind of twenty-first century racial eugenics in which crime and criminology are viewed largely as functions of genetics and biology.

Murphy, 2010

Even if searches never generated any actual discrimination, the mere reliance on offender databases raises an appearance of bias that the criminal justice system can little tolerate. Criticism of the system and its inequities has already deeply divided communities and undermined trust in and cooperation with law enforcement actors. Using offender databases to find relatives sends a message that in cases where there is no evidence of the perpetrator's identity or ethnicity, it is fair to focus suspicion on not just the usual suspects, but also the innocent relatives of the usual suspects. It is misleading for advocates of familial searches to repeatedly suggest that the technique is no more pernicious than looking in a DMV database for a match to a partial license plate. Such an analogy is inaccurate: a search in a DMV database is a search of the entire universe of possible suspects - the DMV database is a registry of all license plates. Instead, a familial search is like looking for partial matches to a license plate, but in a DMV database that contains only cars registered to those with surnames starting with M through Z.

Murphy, 2010

Indeed, on a superficial level, it ought to strike most persons as odd that the groupings are both racially and ethnically composed: distinct categories for "Hispanic" and "African American" make little sense when there are Hispanic persons of African, European, Asian, and Indigenous descent. Scientists simply adopted the categories used to report DNA frequency statistics from those used by the U.S. Census Bureau, despite that they are avowedly "social in character, not biological or genetic." They also depend on self-identification, and entirely ignore bi- and mixed-race persons. Think of the United States' first "black" or "African American" president, Barack Obama, who identifies culturally as African American but who by ancestry is no more black than he is white, and who has written eloquently about his own complex heritage. Racial and ethnic categorizations are simply that: loose and largely social associations based on the self-identification -or the physical appearance - of a suspect.

Murphy, 2010

The second response to the preceding arguments might be to concede the myriad inequities and pitfalls of familial searching, and to instead argue in favor of a population-wide DNA database. Of course, the primary obstacle to such an approach would be the Constitution - in a constitutional regime that struggles with whether to allow the state to demand a person's name without suspicion or whether to create a national identity card a program that requires the compulsory submission of a DNA sample seems highly unlikely to withstand attack.

Murphy, 2010

If, however, the current trend of expansion were to continue-such that not just certain classes of serious offenders, or even all convicted offenders, are to be included, but also mere arrestees-then it seems to me that a certain tipping point is reached . Once databases cease to draw meaningful lines around their constituent populations - and I would classify inclusion of arrestees as such, given the large number of arrests annually-then the corresponding benefits of keeping them small fade. In the face of unmitigated enthusiasm to expand DNA databases, my intuition is to favor a population-wide register as a way of correcting for the problem of inequity, encouraging the population to attend to oversight, and avoiding the actual and expressive entrenchment of extant socioeconomic and racial disparities in the criminal justice system.

Simpson

The Case

6/12/94	Nicole Brown Simpson and Ronald Goldman murdered.
6/17/94	O.J. Simpson arrested.
11/1/94	Criminal trial begins.
10/2/95	Jury acquits Simpson after 4 hours deliberation.
10/23/96	Civil trial begins.
1/4/97	Simpson found liable for wrongful deaths.

Bundy Crime Scene

LAPD Items	Description	Not excluded
42	NB - pool	NB
47	1st drop by victims	OS
48, 49, 50, 52	Bundy Walk	OS
56	Shoe print	NB
78	RG boot drop	NB, RG
84	NB nails	NB
115, 116, 117	Rear gate	OS

Bronco Automobile

LAPD Items	Description	Not excluded
23	Driver door interior	OS
24	Instrument panel	OS
25	Driver side carpet	OS
29	Steering wheel	OS, NB
30	Center console	OS
31	Center console	OS, RG
34	Driver side wall	OS
293	Driver side carpet	NB
303, 304, 305	Center console	OS, NB, RG

Rockingham Residence

LAPD Items	Description	Not excluded
6, 7	Rockingham trail	OS
12	Rockingham foyer	OS
14	Master bath floor	OS

Rockingham Glove

LAPD Items	Description	Not excluded
9	Inside/back of wrist	NB, RG
9:G1	Inside/back index finger	NB, RG
9:G2	Inside/side middle finger	NB, RG
9:G3	Inside-back ring finger	RG
9:G4	Inside-back of hand	NB, RG
9:G9	Inside-by wrist notch	RG
9:G10	Inside-by wrist notch	RG, OS
9:G11	Outside-near wrist notch	NB, RG, OS
9:G12	Outside-near wrist notch	NB, RG
9:G13	Stitching on wrist notch	NB, RG, OS
9:G14	Inside-back of cuff edge	NB, RG

Rockingham Socks

LAPD Items	Description	Not excluded
13	Ankle area 42A-1	NB
	Leg -opposite 42A-1	OS
	Leg - same side as 42A-1	OS
	Upper toe region	OS
	Near ankle	NB
	Near ankle	NB

Nelson

The Case

- 19 year-old Ollie George raped and murdered in February 1976.

- Eyewitnesses led police to Dennis Nelson. Insufficient evidence to charge him.

- Nelson later convicted for other crimes, including rape, and gave a DNA sample.

The Case

- In 2000, California started using DNA typing for cold cases.
- In 2002, a match was found between evidence samples and Nelson's profile in offender database.
- Nelson convicted, and appealed against the match numbers presented at his trial.

The Numbers

"The prosecution presented evidence that the odds that a random person unrelated to defendant from the population group that produced odds most favorable to him could have fit the profile of some of the crime scene evidence are one in 930 sextillion (93 followed by 22 zeros). "

"At the time, the databank contained about 184,000 individual profiles. The search resulted in a match with one of the persons in the databank. Defendant was that person, and he was identified as a potential source of the semen stain. "

Supreme Court Review

" We granted defendant's petition for review limited to the following questions:
(1) Did the delay in charging defendant violate his state and federal constitutional rights?
(2) Does the methodology for assessing the statistical significance of a "cold hit" from a DNA database require proof of general scientific acceptance?
(3) How should the statistical significance of a cold hit from a DNA database be calculated? "

Charging Delay

"In this case, the justification for the delay was strong. The delay was investigative delay, nothing else. The police may have had some basis to suspect defendant of the crime shortly after it was committed in 1976. But law enforcement agencies did not fully solve this case until 2002, when a comparison of defendant's DNA with the crime scene evidence resulted in a match, i.e., until the cold hit showed that the evidence came from defendant.* Only at that point did the prosecution believe it had sufficient evidence to charge defendant."

* Prosecutor's Fallacy.

Prosecutor's Fallacy

"Defendant contends the court erred in admitting the DNA evidence. Specifically, he contends the evidence regarding the odds that the crime scene evidence could have come from some other person* was inadmissible because the statistical method used to calculate those odds has not achieved general scientific acceptance under the standard stated in People v. Leahy (1994) 8 Cal.4th 587 and People v. Kelly (1976) 17 Cal.3d 24 (sometimes referred to as the Kelly test)."

* Close to Prosecutors fallacy.

Product Rule

"Experts use a statistical method called the "product rule" to calculate the rarity of the sample* in the relevant population. As the Court of Appeal summarized it, 'The frequency with which each measured allele appears in the relevant population is estimated through the use of population databases. . . . The frequencies at each tested locus are multiplied together to generate a probability statistic reflecting the overall frequency of the complete multilocus profile. . . . The result reflects the frequency with which the complete profile is expected to appear in the population.' "

* Better to call this the estimated profile probability.

Product Rule

"Defendant does not challenge the validity of the product rule to calculate the relevant odds when a suspect's DNA sample is compared to the crime scene evidence. But he contends that the situation here is different. Here, the match did not come about by comparing a suspect's profile with the crime scene sample but by a cold hit from a database."

Product Rule

"In this case, a database containing about 184,000 DNA profiles was searched to see if any matched the crime scene sample. Defendant's profile came back a tentative match. His complete profile was then compared with the crime scene evidence, resulting in a confirmatory match. The product rule then established the odds the jury heard. Defendant contends use of the product rule in this case is a new scientific technique that must, but does not, pass the Kelly test."

Database Search

"when a suspect is found by a search of a large DNA database, the chance of a coincidental match is increased because 'a single genetic profile (from the crime scene evidence) is compared to the very large number of profiles in these databases.' "

This is correct, but it does not alter the probability that the suspect matches the crime scene evidence.

Four Calculations

"1. One method is the random match probability calculated by use of the product rule. The issue before us is whether this approach is admissible in a cold hit case. "

"2. in a databank search, one set of loci could be used to screen and identify a suspect and then a different set of loci could be used to confirm a match. Statistical analysis using the product rule would be done on the second set of loci." Not done.

Four Calculations

"3. the expected frequency of the profile could be calculated through use of the product rule, and the result could then be multiplied by the number of profiles in the databank. The result would be the expected frequency of the profile in a sample the size of the databank and thus the random chance of finding a match in a sample of that size. " Sometimes called the 'Np' rule.

Np Rule

"As the Court of Appeal explained, the databank here contained about 184,000 profiles. Even if the numbers of this case were divided by 184,000, the resulting numbers would still be astronomical. The odds for Hispanics, the group producing odds most favorable to defendant, would then be about one in five followed by 18 zeros. We agree with the Court of Appeal that 'it seems most unlikely that the difference would be significant to the jury.'
"

Four Calculations

"4. instead of focusing on the probability of obtaining a match, Balding-Donnelly focuses on the elimination of other profiles during the search. In their analysis, a match becomes more significant with larger database searches. They posit that in obtaining a match in a database search, one simultaneously eliminates other profiles as being the source of the sample. This elimination of known persons increases the chances that the identified individual is the actual source of the sample DNA. "

The Balding-Donnelly Rule.

Scientific Certainty

"Indeed, some courts have suggested that, when the odds are like those here, it might be appropriate for the expert to testify that, except for identical twins or maybe close relatives, 'it can be concluded to a reasonable scientific certainty* that the evidence sample and the defendant sample came from the same person.' "

* No obvious meaning.

Fifth Method

No mention was made of the "Balding-Nichols" match probabilities that include θ.

Those numbers would be a lot less extreme than the product-rule profile probabilities.

Summary of Questions

" The rarity statistic simply answers the question: 'How rare is this specific combination of genetic material'?
The database match probability [Np] answers the question: 'What is the chance/probability of obtaining a match by searching this particular database'?
And the Balding-Donnelly calculation answers the question: 'What is the chance/probability that the person identified is the source of the sample in light of the fact that all other persons in the database were eliminated'?
None of the questions are the same; more importantly, none of the answers are mutually exclusive. The debate that exists is solely concerned with which number – rarity, database match probability, Balding-Donnelly, or some combination of the above is most relevant in signifying the importance of a cold hit."

Summary of Questions

The most appropriate question at trial is "What is the probability the defendant's profile matches the crime scene profile if the defendant is not the source of the crime scene profile?" This is the match probability. It does not depend on the database.

Avoiding the Prosecutor's Fallacy

"In a non-cold-hit case, we said that 'it is relevant for the jury to know that most persons of at least major portions of the general population could not have left the evidence samples.' ... this remains true even when the suspect is first located through a database search. The database match probability ascertains the probability of a match from a given database. 'But the database is not on trial. Only the defendant is.' Thus, the question of how probable it is that the defendant, not the database, is the source of the crime scene DNA* remains relevant. The only numbers being presented are probabilities of evidence or matches not probabilities of prosecution or defense hypotheses. The rarity statistic addresses this question."

Interesting Comment

"Defendant was a potential suspect shortly after Ollie George was murdered in 1976. If modern DNA technology and statistical methods had existed then, law enforcement authorities might have compared his DNA to the crime scene DNA and applied the product rule to obtain the same results ultimately obtained after the database search that actually occurred. The relevance and admissibility of the results obtained in that fashion would be beyond question today. The fact that the match ultimately came about by means of a database search does not deprive the rarity statistic of all relevance. It remains relevant for the jury to learn how rare this particular DNA profile is within the relevant populations and hence how likely it is that someone other than defendant was the source of the crime scene evidence*."

* Proscutor's fallacy.

Conclusion

"Accordingly, the trial court correctly admitted the evidence, and the Court of Appeal correctly upheld that admission.

We affirm the judgment of the Court of Appeal. "

But ...

"The conclusion that statistics derived from the product rule are admissible in a cold hit case does not mean that they are the only statistics that are relevant and admissible. The database match probability statistic might also be admissible. As explained, it is unlikely the database match probability statistic would have been significant to the jury in this case given the size of even that number. But in a different case, if the database were large enough and the odds shorter than those here, the database match probability statistic might also be probative. Nothing we say prohibits its admission. "

Brown

The Case

In the early morning hours of January 29, 1994, Jane Doe was sexually assaulted in the bedroom of her trailer home at 1637 Pruett Street in Carlin. Jane Doe and her four-year-old sister were home alone while their mother, Pam, was drinking at a bar, and their step-father, Wayne, was working the night shift at his job. Troy was arrested, tried, and convicted for the crime.

The Case

At trial, Renee Romero testified that she had conducted a DNA test on stains found on Jane Doe's underwear. Romero explained in detail what DNA is and how it is tested. Romero testified that the DNA sample tested from Jane Doe's underwear matched Troy's and that only 1 in 3,000,000 people had the same DNA code as the one tested. Troy's counsel cross-examined Romero regarding how she conducted the tests, the amount of DNA required to run the tests, and the databases against which the DNA tests were compared to determine the statistical probability that others would have the same DNA code. However, Troy's counsel did not call his own expert DNA witness even though the court provided funds for such a witness.

Nevada Supreme Court, February 26, 1997

Appellant Troy Brown was tried and convicted of sexually assaulting Jane Doe, a nine-year-old girl. Troy was convicted of two counts of sexual assault of a child under fourteen years of age, and one count of child abuse by sexual abuse. He was acquitted of one count of attempted murder. Troy claims on appeal that (1) he was improperly denied bail; (2) the DNA evidence was improperly admitted because no evidentiary hearing was held; (3) sufficient evidence did not exist to support his conviction; (4) double jeopardy barred his convictions for both sexual assault and child abuse by sexual abuse; and (5) the district judge abused his discretion during the sentencing phase of the trial.

Nevada Supreme Court, February 26, 1997

We conclude that the district judge properly denied bail for Troy, that the DNA evidence was properly admitted at trial, and that sufficient evidence existed to support Troy's conviction. However, we conclude that Troy's conviction for both sexual assault and child abuse by sexual abuse violated the double jeopardy provision of the Constitution and that the conviction for child abuse must be vacated. Finally, we conclude that the district judge abused his discretion during the sentencing phase of the trial and the case must be remanded to the district court for a new sentencing hearing on the remaining sexual assault conviction.

US District Court, February 6, 2004

On February 6, 2004, Troy filed his federal petition for writ of habeas corpus pursuant to 28 U.S.C. 2254, arguing, inter alia, violations of due process and ineffective assistance of counsel. Judge Pro permitted Troy to expand the record, admitting, among other things, an uncontested report discrediting Romero's testimony by Dr. Laurence Mueller (the "Mueller Report"), a professor of Ecology and Evolutionary Biology at the University of California, Irvine.

US District Court, February 6, 2004

The district court granted Troy's petition. First, the district court concluded that, in light of the Mueller Report, Romero's testimony was unreliable. Absent that testimony, no rational trier of fact could conclude beyond a reasonable doubt that Troy was guilty of each and every element of the offenses with which he was charged. The district court also concluded that Troy's attorney's failure to diligently defend against Respondents' DNA testimony, as well as his failure to investigate the alibi of Henle, a potential suspect, amounted to ineffective assistance of counsel. Respondents [the State of Nevada] timely appealed.

US Court of Appeals, May 8, 2008

At trial, Respondents presented the testimony of DNA expert Renee Romero of the Washoe County Sheriff's Office Crime Lab. Romero testified that, among other things, there was a 99.99967 percent chance that Troy was the assailant.

At Petitioner Troy Brown's trial for sexual assault, the Warden and State's ("Respondents") deoxyribonucleic acid ("DNA") expert provided critical testimony that was later proved to be inaccurate and misleading. Respondents have conceded at least twice that, absent this faulty DNA testimony, there was not sufficient evidence to sustain Troy's conviction. In light of these extraordinary circumstances, we agree with District Judge Philip M. Pro's conclusions that Troy was denied due process, and we affirm the district court's grant of Troy's petition for writ of habeas corpus.

US Court of Appeals, May 8, 2008

Troy asserts that there was insufficient evidence to convict him. His argument rests on the admission of Romero's later discredited testimony regarding the DNA evidence, which was introduced without rebuttal at trial. Respondents have conceded that absent introduction of Romero's DNA evidence, the remaining evidence is insufficient to sustain Troy's conviction. Having reviewed the record ourselves, we affirm the district court's conclusion that, had Romero's inaccurate and unreliable testimony on the DNA evidence been excluded, there would have been insufficient evidence to convict Troy on each essential element of the offenses beyond a reasonable doubt. We further agree with the district court's conclusion that the Nevada Supreme Court's decision was both "contrary to" and an "unreasonable application of" established United States Supreme Court precedent.

US Court of Appeals, May 8, 2008

The Mueller Report indicates that Romero's testimony was unreliable for two main reasons. First, Romero testified that there was a 99.99967 percent chance that Troy's DNA was the same as the DNA discovered in Jane's underwear – or, in other words, that the science demonstrated a near 100 percent chance of Troy's guilt. This assertion was incorrect, as it falls directly into what has become known as the "prosecutor's fallacy." The prosecutor's fallacy occurs when the prosecutor elicits testimony that confuses source probability with random match probability. Put another way, a prosecutor errs when he "presents statistical evidence to suggest that the [DNA] evidence indicates the likelihood of the defendant's guilt rather than the odds of the evidence having been found in a randomly selected sample." ... the prosecutor's fallacy "could lead to serious error, particularly where the other evidence in the case is weak and therefore the prior probability of guilt is low".

US Court of Appeals, May 8, 2008

Here, Romero initially testified that Troy's DNA matched the DNA found in Jane's underwear, and that 1 in 3,000,000 people randomly selected from the population would also match the DNA found in Jane's underwear (random match probability). After the prosecutor pressed her to put this another way, Romero testified that there was a 99.99967 percent chance that the DNA found in Jane's underwear was from Troy's blood (source probability). This testimony was misleading, as it improperly conflated random match probability with source probability. In fact, the former testimony (1 in 3,000,000) is the probability of a match between an innocent person selected randomly from the population; this is not the same as the probability that Troy's DNA was the same as the DNA found in Jane's underwear, which would prove his guilt.

US Court of Appeals, May 8, 2008

Statistically, the probability of guilt given a DNA match is based on a complicated formula known as Bayes's Theorem, see id. at 170-71 n. 2, and the 1 in 3,000,000 probability described by Romero is but one of the factors in this formula. Significantly, another factor is the strength of the non-DNA evidence. Here, Romero improperly conflated random match and source probability, an error that is especially profound given the weakness of the remaining evidence against Troy. In sum, Romero's testimony that Troy was 99.99967 percent likely to be guilty was based on her scientifically flawed DNA analysis, which means that Troy was most probably convicted based on the jury's consideration of false, but highly persuasive, evidence.

US Court of Appeals, May 8, 2008

Second, Romero inaccurately minimized the likelihood that Troy's DNA would match one of his four brothers' DNA, thus underestimating the likelihood that one of Troy's brothers could have been the perpetrator. She testified that there was a 25 percent chance of two brothers sharing both alleles at one locus, and, using that figure, a 1/6500 chance that one of Troy's brothers would match Troy's DNA at all five loci. The Mueller Report indicated that Romero's calculation was incorrect, as the correct figure is 1/1024.

US Court of Appeals, May 8, 2008

More importantly, Romero's testimony is misleading because it presented the narrowest interpretation of the DNA evidence. Had Romero accounted for Troy's four brothers, two of whom lived in Carlin and two of whom lived in neighboring Utah, the chance that Troy's DNA would match at least one of his four brothers' DNA can increase to 1/66 – almost one hundred times the probability asserted by Romero. This omission was especially egregious given that the victim, Jane, had twice identified Troy's brother, Trent, as the assailant. Again, Respondents introduced nothing to contradict the findings of the Mueller Report.

. . . The district court's grant of Troy's petition for writ of habeas corpus and reversal of his conviction is AFFIRMED. Respondents shall retry Troy within 180 days or shall release him from custody.

Dissenting Opinion on US Court of Appeals

The Nevada Supreme Court properly considered the evidence, including the DNA evidence, as it was presented by the prosecution at trial. The compelling force of the DNA evidence, coupled with the strong circumstantial evidence and inferences supported by the totality of the evidence, firmly grounded the Nevada Supreme Court's decision.

Brief of 20 Scholars of Forensic Evidence, July 24, 2009

Ms. Romero testified that she tested both the crime-scene evidence and a known sample from Troy Brown using a DNA testing technique known as Restriction Fragment Length Polymorphism (RFLP) analysis. Examining five loci, or places on the genomic strand, Ms. Romero concluded that Troy possessed a set of genetic characteristics that were also found in a semen stain on the victim's underwear.

Ms. Romero was then asked to explain the strength of that match to the jury. Using what she repeatedly described as a "conservative" method, she reported that the likelihood that this particular genetic profile would be found in the population is roughly "one in 3 million."

Brief of 20 Scholars of Forensic Evidence, July 24, 2009

The prosecutor then engaged in a series of exchanges, including a visual demonstration, intended to present this "one in 3 million" statistic in various – and he reiterated, equivalent – ways. The prosecutor invited Romero to present "another way to show that statistic" asking specifically "what is the likelihood that the DNA found in the panties [was from the defendant]" and "what would that percentage be?" Ms. Romero responded: "It would be 99.99[9]967 percent. The prosecutor then asked the expert to write that percentage on a board and to subtract it from 100 percent. The display, which became Exhibit G, shows the numbers as follows:

$$\begin{array}{r} 100.000000 \\ -99.999967 \\ \hline .000033 \end{array}$$

Brief of 20 Scholars of Forensic Evidence, July 24, 2009

The prosecutor then asked whether it would be "fair to say" that "the likelihood that it is not Troy Brown would be .000033?" and that "just another way of looking at it" would be to say that "the chances that the likelihood that it's not the same would be .000033?" The expert agreed that the two expressions were equivalent, adding "[t]hats the way the math comes out". Underscoring the point, the judge said: "Lets make sure. It's the same thing – it's the same math just expressed differently. Is that correct?" The witness responded: "Yes. Exactly, your Honor."

Davie Kaye

Kaye DH. 2009. "False but highly persuasive": How wrong were the probability estimates in McDaniel v. Brown. 108 Michigan law Review First Impressions 17.

"Indeed, the [Prosecutor's] fallacy abounds in the statements of judges, defense counsel, and journalists. Statistics textbooks, evidence casebooks and treatises, and judicial opinions all caution against it. Consequently, the [Mueller] letter is hardly necessary for an appellate court to take cognizance of the transposition. The lower courts were therefore justified in considering the error regardless of whether the Mueller letter is officially part of the record."

Davie Kaye

"Moreover, even with a cumulative [match probability] of 1 in 66, the jury could reasonably conclude that, in light of other evidence indicating the lack of involvement of any brother, Troy almost certainly was the source of the DNA."

US Supreme Court, January 11, 2010

A Nevada jury convicted respondent of rape; the evidence presented included DNA evidence matching respondent's DNA profile. Nevertheless, relying upon a report prepared by a DNA expert over 11 years after the trial, the Federal District Court applied the Jackson standard and granted the writ. A divided Court of Appeals affirmed. Brown v. Farwell, 525 F. 3d 787 (CA9 2008). We granted certiorari to consider whether those courts misapplied Jackson. Because the trial record includes both the DNA evidence and other convincing evidence of guilt, we conclude that they clearly did.

US Supreme Court, January 11, 2010

Respondent thereafter filed this federal habeas petition, claiming there was insufficient evidence to convict him on the sexual assault charges and that the Nevada Supreme Court's rejection of his claim was both contrary to, and an unreasonable application of, Jackson. He did not bring a typical Jackson claim, however. Rather than argue that the totality of the evidence admitted against him at trial was constitutionally insufficient, he argued that some of the evidence should be excluded from the Jackson analysis. In particular, he argued that Romero's testimony related to the DNA evidence was inaccurate and unreliable in two primary respects: Romero mischaracterized the random match probability and misstated the probability of a DNA match among his brothers. Absent that testimony, he contended, there was insufficient evidence to convict him.

US Supreme Court, January 11, 2010

In support of his claim regarding the accuracy of Romero's testimony, respondent submitted a report prepared by Laurence Mueller, a professor in ecology and evolutionary biology (Mueller Report). ...

Mueller instead contends that Romero committed the so-called prosecutors fallacy and that she underestimated the probability of a DNA match between respondent and one of his brothers.

US Supreme Court, January 11, 2010

The prosecutor's fallacy is the assumption that the random match probability is the same as the probability that the defendant was not the source of the DNA sample. ... In other words, if a juror is told the probability a member of the general population would share the same DNA is 1 in 10,000 (random match probability), and he takes that to mean there is only a 1 in 10,000 chance that someone other than the defendant is the source of the DNA found at the crime scene (source probability), then he has succumbed to the prosecutors fallacy. It is further error to equate source probability with probability of guilt, unless there is no explanation other than guilt for a person to be the source of crime-scene DNA. This faulty reasoning may result in an erroneous statement that, based on a random match probability of 1 in 10,000, there is a .01% chance the defendant is innocent or a 99.99% chance the defendant is guilty.

US Supreme Court, January 11, 2010

The Mueller Report does not dispute Romeros opinion that only 1 in 3,000,000 people would have the same DNA profile as the rapist. Mueller correctly points out, however, that some of Romeros testimony – as well as the prosecutors argument – suggested that the evidence also established that there was only a .000033% chance that respondent was innocent. The State concedes as much. Brief for Petitioners 54. For example, the prosecutor argued at closing the jury could be "99.999967 percent sure" in this case. App. 730. And when the prosecutor asked Romero, in a classic example of erroneously equating source probability with random match probability, whether "it [would] be fair to say . . . that the chances that the DNA found in the panties –the semen in the panties – and the blood sample, the likelihood that it is not Troy Brown would be .000033," id., at 460, Romero ultimately agreed that it was not inaccurate to state it that way, id., at 461462.

US Supreme Court, January 11, 2010

Looking at Romero's testimony as a whole, though, she also indicated that she was merely accepting the mathematical equivalence between 1 in 3,000,000 and the percentage figure. At the end of the colloquy about percentages, she answered affirmatively the courts question whether the percentage was the same math just expressed differently. Id., at 462. She pointed out that the probability a brother would match was greater than the random match probability, which also indicated to the jury that the random match probability is not the same as the likelihood that someone other than Troy was the source of the DNA.

US Supreme Court, January 11, 2010

The Mueller Report identifies a second error in Romeros testimony: her estimate of the probability that one or more of Troys brothers DNA would match. Romero testified there was a 1 in 6,500 (or .02%) probability that one brother would share the same DNA with another. Id., at 469, 472. When asked whether that change[s] at all with two brothers, she answered no. Id., at 472. According to Mueller, Romero's analysis was misleading in two respects. First, she used an assumption regarding the parents under which siblings have the lowest chance of matching that is biologically possible, but even under this stingy assumption she reported the chance of two brothers matching (1 in 6,500) as much lower than it is (1 in 1,024 under her assumption).

US Supreme Court, January 11, 2010

Second, using the assumptions Mueller finds more appropriate, the probability of a single sibling matching respondent is 1 in 263, the probability that among two brothers one or more would match is 1 in 132, and among four brothers it is 1 in 66. Id., at 1583.

In sum, the two inaccuracies upon which this case turns are testimony equating random match probability with source probability, and an underestimate of the likelihood that one of Troys brothers would also match the DNA left at the scene.

US Supreme Court, January 11, 2010

We have stated before that "DNA testing can provide powerful new evidence unlike anything known before." ... Given the persuasiveness of such evidence in the eyes of the jury, it is important that it be presented in a fair and reliable manner. The State acknowledges that Romero committed the prosecutor's fallacy, Brief for Petitioners 54, and the Mueller Report suggests that Romero's testimony may have been inaccurate regarding the likelihood of a match with one of respondent's brothers.

US Supreme Court, January 11, 2010

Regardless, ample DNA and non-DNA evidence in the record adduced at trial supported the jury's guilty verdict under Jackson, and we reject respondent's last minute attempt to recast his claim under Brathwaite. The Court of Appeals did not consider, however, the ineffective-assistance claims on which the District Court also granted respondent habeas relief. Accordingly, the judgment of the Court of Appeals is reversed, and the case is remanded for further proceedings consistent with this opinion.

It is so ordered.

Justice Thomas' Concurrence

I write separately because I disagree with the Court's decision to complicate its analysis with an extensive discussion of the Mueller Report. See ante, at 713. Defense counsel commissioned that report 11 years after respondent's trial. See ante, at 1. Accordingly, the report's attacks on the State's DNA testimony were not part of the trial evidence and have no place in the Jackson inquiry. See Jackson, supra, at 318; Lockhart, supra, at 4042. That is all we need or should say about the report in deciding this case.

Knox

The Case: Pro-prosecution source

"Rudy Guede was convicted for his part in the murder in October 2008 (confirmed by the Supreme Court of Cassation in December 2010). In a separate trial, Amanda Knox and Raffaele Sollecito were found guilty in December 2009 by the 1st instance court of Judge Massei. A subsequent appeal resulted in their convictions being (provisionally) overturned for the most part, in October 2011. This court upheld Amanda's conviction for calunnia, and increased her sentence to one commensurate with the time she had served so far.

This decision was appealed again by three sides: the prosecution and lawyers representing the Kercher family against the murder acquittal, and Amanda against her calunnia conviction. On March 26, 2013 the Supreme Court of Cassation finalized the calunnia conviction, nullified the acquittal, and ordered a new appeal. This appeal was held in Florence, starting in September 2013 and resulted in Knox and Sollecito's convictions being upheld.

On March 27, 2015 the Court of Cassation in a surprise decision acquitted Amanda Knox and Raffaele Sollecito."

http://themurderofmeredithkercher.com

Calunnia

"Calunnia, meaning "calumny", is a criminal offence under Article 368 of the Italian Penal Code (Codice Penale), which states:
Anyone who with a denunciation, complaint, demand or request, even anonymously or under a false name, directs a judicial authority or other authority that has an obligation to report, to blame someone for a crime who he knows is innocent, that is he fabricates evidence against someone, shall be punished with imprisonment from two to six years. The penalty shall be increased if the accused blames someone of a crime for which the law prescribes a penalty of imprisonment exceeding a maximum of ten years, or another more serious penalty. The imprisonment shall be from four to twelve years if the act results in a prison sentence exceeding five years, from six to twenty years if the act results in a life sentence.

The *mens rea* of calunnia requires awareness and a willingness to blame someone of a crime that the accused knows is innocent."

Wikipedia.

Calunnia Details

"Patrick Lumumba, the Congolese bar owner who was wrongfully accused by Knox of having murdered Kercher, was admitted as a civil plaintiff in the trial. His lawyer said he was owed more than 100,000 euros (84,000 pounds) in legal fees from the affair.

Lumumba said Knox's false accusation had ruined his business and made him "the second victim" of Kercher's killing. In its judgment in March the supreme court upheld Knox's conviction for slander."

http://www.theguardian.com/world/2013/sep/30/amanda-knox-retrial-dna-test-murder-weapon

The Case:Pro-defense source

"Here you will find a translation of the report submitted by Profs. Carla Vecchiotti and Stefano Conti of the University of Rome La Sapienza to the Corte di Assise di Appello (Court of Appeals) of Perugia, Italy, regarding DNA evidence in the case against Amanda Knox and Raffaele Sollecito. Vecchiotti and Conti were appointed by the presiding judge in Knox and Sollecito's appeal trial, Claudio Pratillo Hellmann, to conduct an independent review of this evidence, which (like most of the evidence in the case) had long been seriously questioned by Knox and Sollecitos defense teams and by outside observers.

The conclusions reached by Conti and Vecchiotti constitute a damning indictment of the investigation conducted by Italy's Scientific Police, and in particular of the methods employed by the prosecution's main forensic scientist, Dr. Patrizia Stefanoni. They lend official support to the already-widespread perception that Knox and Sollecito have been the victims of a scandalous miscarriage of justice."

http://knoxdnareport.wordpress.com

Gill Interview

"The question is often not so much whether the DNA profile has originated from one particular individual. Rather, it is more to do with how did it get there, when did it get there? The problem with a DNA profile is that there is absolutely no information in it whatsoever that tells you when or how it was deposited, or how it became evidence. DNA doesn't come with a date stamp attached to it. ... Essentially for any case there are three possibilities. It is possible a DNA profile may be deposited before a crime event; it may be deposited during the crime event, as a result of contact between perpetrator and victim, for example; or the third possibility is that the DNA profile may be deposited on the evidence after the crime event has occurred. And the latter would be typically associated with a contamination event. "

http://www.amandaknoxcase.com/peter-gill-interview/

Gill Interview

"There is one case I can allude to, which is the case of Adam Scott. A man was accused of a rape, because his DNA profile was obtained from the swabs - the vaginal swabs, and it matched a man who was some hundreds of kilometres away from the crime scene. And he denied ever having been in the place in his life. The evidence was the DNA profile. He was arrested and incarcerated for about six months, and all the time he was protesting his innocence. Luckily for him it came to light that there had been a contamination event in the actual laboratory. His DNA profile had actually been submitted to the same laboratory a couple of weeks previously, and his DNA profile from that particular event from saliva, was transmitted into the casework analysis for the second system. So of course he came up positive for this particular case, but his DNA had actually been transferred from a previous event. "

Peter Gill: bra clasp

"In the case of the bra clasp, there is certainly (Sollecito's) DNA on the bra clasp, ... but what does it mean? ... Is it possible that Sollecito's DNA has been transmitted from one area of the crime scene to another? ... The investigators themselves actually become vectors of DNA. For example, if an investigator touches a door handle and then proceeds into the crime scene, and then touches the bra clasp, without changing gloves in between, then I would actually expect DNA transfer to occur. And I think I would be surprised if it did not occur, actually. ... My understanding is that there were no DNA swabs taken from the door handle, from the outside, for example, and therefore Sollecito's DNA profile was not actually recovered outside the room. But my point is, there is considerable uncertainty in the case, because it is not denied that Sollecito had access to the flat, and therefore his DNA will be present in the flat. Then the question is 'what is the significance of finding DNA on the bra clasp? And what are the possible methods of transfer?' "

http://www.amandaknoxcase.com/peter-gill-interview/

Greg Hampikian

“ he [Hampikian] had his students mimic part of the investigation in Italy. They collected five soda cans from the office of BSU’s dean of arts and sciences after lunch and put them in individual evidence bags. Then, without changing gloves, they put five newly bought knives into separate evidence bags. Like the Italians, Hampikian’s group looked for DNA at levels below the FBI-recommended minimum. They found DNA from a member of the dean’s staff on one of the knife blades. Yet that person had not touched or even been in the same room with the knives.”

http://www.sciencemag.org/news/2016/03/when-dna-snares-innocent

Peter Gill: knife

"My understanding is that there was DNA from Amanda Knox on the handle, and trace DNA evidence of Meredith Kercher on the blade. However the DNA profile on the blade, purported to be from Meredith Kercher was extremely weak, and furthermore there was no evidence whatsoever of any blood. But there was evidence of starch grains which was evidence that the knife was used to cut food. So the main question is 'was the knife used to stab Meredith Kercher?' And obviously part of the evidence is the DNA profile on the knife handle, which matched Amanda Knox. But there are obviously two possibilities; either the knife was used to stab Kercher, or else it was used to prepare food and it was not used to stab Kercher. And the question is 'can DNA profiles distinguish between the two events?' And it clearly cannot, because the DNA profile gives us no information about how it was transferred. The DNA profile which I would observe on the handle of a knife would be the same regardless of whether the knife had been used to cut food or to stab a victim. I have seen some evidence from the judgement where it has been proposed that the distribution of the DNA on the knife handle is evidence that it was used to stab rather than to cut food, but there is absolutely no scientific evidence, there are no scientific papers whatsoever that would support this kind of conclusion. "

Peter Gill: knife

So again the DNA profile takes us no further forward to decide whether it was transferred as the result of a cutting action as opposed to a stabbing action. The DNA profile purported to come from Meredith Kercher is extremely low level, and again we have to consider the same possibilities of how it got there. Either it was used as a murder weapon, or else the DNA could have been transferred as a result of a contamination event. It's said that the knife has been cleaned with bleach, for example, which is why there is a small amount of material purported to come from Meredith Kercher, but I actually find it quite difficult to believe that bleach would selectively remove blood and leave some DNA there. And it's also another example where no experiments have been carried out to verify whether these conclusions are feasible. I would actually carry out some experiments to take some knives; I would do careful controls I would put blood on the knife blade, I would clean it with bleach for example, to see whether the DNA was selectively removed or stayed intact. But these types of experiments have not been carried out, and therefore all I see with this is quite a lot of speculation."

http://www.amandaknoxcase.com/peter-gill-interview/

Knife DNA Evidence: Prosecution

Solliceto and Knox were complicit in crime, along with Guede.

No murder weapon found at crime scene in Kercher's apartment. Weapon must have been removed.

A large knife found in cutlery drawer of Soliceto's apartment.

DNA profile matching Knox found on knife handle, low-level profile matching Kercher found on blade.

DNA was transferred to handle when Knox stabbed Kercher with the knife. DNA from Kercher was consequently transferred to blade.

Knife DNA Evidence: Defense

Solliceto and Knox not present when crime was committed.

The knife found in the cutlery drawer was not the murder weapon.

DNA matching Knox on the handle was transferred during the preparation of food.

If the DNA on the knife was from Kercher, no evidence it was from blood and the method of transfer is not known (could be by contamination through mishandling of evidence, or by innocent secondary transfer.

Official Knife Test Results

"Results: Among all the analyzed samples belonging to Rep. 36 only the samples labelled A and B furnished a useful genetic profile; more precisely, from sample A it is possible to extrapolate the genetic profile of KNOX, Amanda Marie (comparison conducted against the genetic profile established on page 65 table 31, referred to as Rep. 31, a salivary swab taken from the same individual) while from sample B it is possible to extrapolate the genetic profile of KERCHER, Meredith Susanna Cara, as shown in table 12-1 (comparison conducted against the genetic profile established on on page 49 referred to as Rep21, a blood swab taken from the largest wound present on the neck of the victim.) The analyses of the remaining samples listed in Rep. 36 (called traces C,D,E,F,G) have not provided any useful result."

http://www.injusticeinperugia.org/kniferesults.html

Propositions for Kercher knife evidence

Sub-source level.

Source level.

Activity level.

Ultimate issue.

Balding: Bra clasp

Table 1. Allele calls at 5 of 15 loci in the DNA profile obtained from exhibit 165B (case of Knox and Sollecito)

Locus	Trial*	Appeal†	New‡
D8	13, 15, 16	11, 12, 13, 14, 15, 16	11, 12, 13, 14, 15, 16
D21	30, 32.2, 33.2	29, 30, 32.2, 33.2	29, 30, 32.2, 33.2
D7	8, 11	8, 10, 11	8, 10, 11
CSF	10, 12	10, 11, 12	10, 11, 12
D3	14, 16, 17, 18	14, 15, 16, 17, 18	14, 15, 16, 17, 18
LR§	7×10^{15} (15.8 bans)	4×10^{7} (7.6 bans)	5×10^{10} (10.7 bans)

*Alleles reported at the original trial.
†Alleles identified by Vecchiotti and Conti (2); underlined alleles have peak heights <50 relative fluorescent units.
‡Apparent stutters are also underlined (peaks with a height <15% of the peak height at one extra repeat unit).
§LR for Sollecito to be a contributor of DNA, given that Kercher is a contributor, based on all 15 loci [x bans means $\log_{10}(\mathrm{LR}) = x$].

Balding DJ. 2013. PNAS 110:12241-12246.

Balding: Bra clasp

> Note that I cannot address here issues of how the DNA came to be in the exhibit: Possible contamination was an issue in the trial and appeal. I only consider whether there is DNA from Sollecito for which the evidence remains very strong after allowing for the additional alleles identified by Vecchiotti and Conti (2) and the possibility that apparent stutters are allelic.

Balding DJ. 2013. PNAS 110:12241-12246.

Gill Book

5.6 THE KNIFE (ITEM 36)

5.6.1 Prosecution Propositions

1. Sollecito and Knox were alleged to be complicit in the crime along with Rudy Guede.
2. A murder weapon had not been discovered at or near the crime scene, therefore the weapon must have been removed.
3. A large knife (item 36) was found remote from the crime scene in a cutlery drawer in Sollecito's flat. The investigators alleged this to be the murder weapon.
4. The knife was tested for DNA and a profile matching Amanda Knox was found on the handle and a low-level profile matching Meredith Kercher was found on the blade.
5. The prosecution alleged that the DNA was transferred to the handle when Knox stabbed Kercher with the knife (and DNA from Kercher was consequently transferred to the blade).

5.6.2 Defense Alternative Propositions

1. Sollecito and Knox were not present when the crime was committed
2. The murder weapon was not the knife found in the cutlery drawer
3. The "trace-DNA" attributed to Knox on the handle was transferred during preparation of food (she prepared meals at Sollecito's apartment)
4. If the "trace-DNA" profile originates from Kercher (a) there is no evidence it originated from blood and (b) the transfer method is unknown, but could have occurred either by contamination (mishandling the evidence) or by secondary transfer (innocent transfer)

5.7 THE "TRACE-DNA" EVIDENCE

There appeared to be no *a priori* evidence that the knife selected from a cutlery drawer was the murder weapon (it was not covered with blood for example). The only reason that it was selected was because of an "investigative hunch" by a police officer. No other cutlery in the drawer was analyzed. The knife selected, Exhibit 36, appeared very clean, with nothing visible to the naked eye. Two profiles were obtained at the initial investigation:

36-A (handle of the knife): A single contributor DNA profile that matched Amanda Knox

36-B (blade of the knife): A single contributor (low-level) DNA profile that matched the victim, Meredith Kercher.

Gill Book

5.7.1 Comment on the Method of Analysis

There was fair criticism in the Conti-Vechiotti report of the method used to analyze the DNA profiling evidence. The profiles have since been reanalyzed using methods that can take account of the drop-in and drop-out phenomena associated with low-template DNA, using LRmix (Gill and Haned, 2013; Haned, 2011; Haned and Gill, 2011; Haned et al., 2012), using methods supported by the ISFG DNA Commission (Gill et al., 2012). In the latest analysis of a profile from the knife handle/junction of the knife blade, the Carabinieri also followed this method. New evidence submitted to the latest court inquiry: 36-I (junction of handle and blade of knife) revealed a two person mixture attributed by the prosecution to Amanda Knox and an unknown individual. http://www.amandaknox.com/wp-content/uploads/2013/07/Perizia-biologico-forense-PP-11-13-RG-AA-CAA-Firenze_31-10-2013.pdf. The following is an example of a standard method of reporting crime-stain evidence that utilizes the likelihood ratio method. The report is conditioned on the alternative propositions (under the assumption that each is true).

Two alternative propositions were considered at the sub-source level:

Either: under the prosecution hypothesis (Hp): the DNA profile is a mixture and originated from Amanda Knox and one unknown person.
Or: Under the defense hypothesis (Hd): the DNA profile is a mixture and it originated from two unknown persons.

The conclusion: The evidence is 700 million times more likely if the DNA profile originated from Amanda Knox and one unknown person than if it originated from two unknown persons.

Comment: Note that the standard report is restricted to an assessment of the DNA profiling evidence at sub-source level.

5.8 BRIEF SUMMARY OF THE OTHER "TRACE-DNA" PROFILES ON THE KNIFE

The profile attributed to Knox in item 36-A was unambiguous (single contributor). The profile attributed to the victim, Meredith Kercher, on the knife blade was very low level; many alleles were below the usual detection threshold of 50 rfu (rfu are measurement units) and I counted just six alleles above the threshold level, although those below the threshold level did not

Gill Book

exclude Kercher. It is standard practice to include only those alleles above the threshold, in the likelihood ratio test. This profile was nevertheless at the limits of detection and originated from just a handful of cells—this is the kind of profile I would expect to observe, if it had originated from a contamination event. The DNA-trace evidence was calculated LR = 100 in favor of the prosecution hypothesis if it originated from Kercher (weak evidence).

5.9 THE BRA-CLASP (ITEM 165)

There has been an independent analysis of item 165 (bra-clasp) by Balding (2013) using LikeLTD software. The results are consistent with those reported here.

A bra-clasp was found at the crime scene. It had been physically cut from the victim during the offence. This item revealed a complex mixture. Analysis of the DNA profile by defense experts (Vecciotti-Conti report) indicated that it was not unreasonable to postulate three or more contributors. Note that a complex DNA profile does not explicitly provide the absolute number of contributors. There was a major contribution to the DNA profile from the victim (unsurprisingly) and the remaining foreign alleles were all very low level. The precise conditioning on the number of contributors is therefore difficult to determine. In this case the following propositions were tested using exactly the same format as described in the previous section:

Under Hp: The "trace-DNA" profile is a mixture of Sollecito, two unknown individuals and the victim Meredith Kercher
Under Hd: The "trace-DNA" profile is a mixture of three unknown individuals and the victim Meredith Kercher

Conclusion: The evidence is 2.59 million times more likely if the "trace-DNA" profile is a mixture of Sollecito, Kercher and two unknown individuals compared to the alternative proposition that it is a mixture of Kercher and three unknown individuals *(because Sollecito is innocent under the defense proposition he is replaced by an unknown individual in the statistical analysis under the defense argument).*

Comment: Once again, the assessment of the strength of the evidence is at sub-source level and deliberately ignores the method of transfer.

Gill Book

Bearing in mind we are still evaluating the evidence at the *sub-source* level: the advantage of the LRmix analysis is that it allows "exploratory analysis" to be carried out. This means that the defense and the prosecution scientists can carry out "what-if" scenario analysis. With the example of the bra-clasp, the number of contributors was uncertain—how robust is the statistical analysis if the number of contributors is wrong? To test this, the number of contributors was increased to five individuals. Now the following propositions were compared:

Under Hp: The "trace-DNA" profile is a mixture of Sollecito, *three* unknown individuals and the victim Meredith Kercher.
Under Hd: The "trace-DNA" profile is a mixture of *four* unknown individuals and the victim Meredith Kercher.

Conclusion: The evidence is 181,500 times more likely if the DNA profile was a mixture of Sollecito, Kercher and three unknown individuals.

Comment: The evidence is still probative, although there is an order of magnitude reduction in the likelihood ratio.

5.10 HOW ROBUST IS THE ANSWER?

The strength of evidence that is generated in the form of the likelihood ratio is a standard method of reporting DNA evidence. The method directly compares the alternative scenarios that are proposed by the defense and the prosecution. In this example, the answers are relatively insensitive to postulating more unknown contributors. However, a raw likelihood ratio that is based upon complex alternative propositions does require extra qualification to ensure the calculation is robust. The following question is addressed:

What values of strength of evidence will be obtained if we replace Sollecito with a random person?

If the model is robust, it will be able to discriminate between a randomly chosen individual and a "true donor" to the mixture, because the former should give a very low "exclusionary" statistic (LR less than one). In Section 4.7, it was noted that a robust statistical method should be able to provide strength of evidence that supports the "defense hypothesis of exclusion." We evaluate the chance that a high likelihood ratio would be obtained from a random man substitution of the suspect.

Cassation Court Acquittal

More unusual – and disturbing – is the fate of the bra clasp.

Noticed during the first site inspection by the Scientific Police, the object was ignored and left there on the floor for quite some time (a good 46 days), until it was finally collected during an additional visit. It is certain that in the time period between the site inspection when it was noticed and the one when it was collected, there were other visits by the investigators, who rummaged everywhere, moving furniture and fixtures, in search of evidence that would be useful to the investigation. The clasp was perhaps trodden on or, in any case, moved (such that it was found on the floor in a different position from where it had initially been noticed). Not only this, but the photographic documentation produced by Sollecito's defence demonstrates that, at the time of the collection, the clasp was passed from hand to hand by the agents, who in addition were wearing dirty latex gloves.

Cassation Court Acquittal

Regarding the biological traces, marked with the letters A and I (the latter examined by the RIS [*Reparto investigazioni scientifiche | Department of scientific investigation*]), found on the knife seized from Sollecito's home and bearing Knox's genetic profile, this is a neutral element, given the accused lived with Sollecito in his home on via Garibaldi, although continuing to also live in via della Pergola, and - as has been pointed out - this utensil showed no traces of Kercher's blood, a negative circumstance which contradicts the prosecution's hypothesis that it was the murder weapon.

Cassation Court Acquittal

On this point, it has to be stressed that – yet again due to the questionable choice of the scientific police's geneticists - it was decided to favour investigations aimed at identifying the genetic profile of the traces found on the knife, rather than discover their biological nature, given that the small quantities of the samples did not allow the analysis to be repeated: in fact the qualitative examination apparently "used up" the sample and made it useless for further investigations. An extremely questionable choice, given that the finding of blood traces, coming from Kercher, would have given the trial an element of strong evidentiary value, showing for certain that the weapon had been used to commit the murder. The established presence in Sollecito's home [of Kercher's blood trace], given Knox lived there, would have led, then, to a possible deduction on the matter. Instead, finding that the traces matched Knox's genetic profile is not considered unequivocal data and indeed irrelevant, given that the young American lived with Sollecito, some of the time in his home and some of the time on via della Pergola. Not only this, but even if it had been possible to attribute trace B with certainty to Kercher's genetic profile, as evidence in the trial it would not have been decisive (not being a blood trace), taking into account the promiscuity and commonality of interpersonal relationships, typical of students living away from home, which make it plausible that a kitchen knife or other utensil could be moved from one home to another and that, therefore, the confiscated knife could have been moved by Knox to via della Pergola for domestic use, on the occasion of parties or other events, and thus also used by Kercher.

Gill Interview

"The first thing to do is to forget everything that you think you know about forensic science that you have gathered from TV shows. ... Everyone is so blinded by the huge power of DNA profiling that the obvious falls by the wayside. So DNA always has to be considered in the context of the other evidence, and should never be considered by itself."

http://www.amandaknoxcase.com/peter-gill-interview/