A recent case

"Items analyzed: Known buccal from X, Y, Z. Based on the DNA profiles obtained from the samples listed above (13 core loci), X cannot be excluded as the possible biological father of Y, assuming Z is the biological mother of Y.

Population	Combined Paternity Index
Caucasian	3,435,000
African-American	21,570,000
Native American Popn A	484,600
Native American Popn B	5,256,000
Native American Popn B	2,408,000

Combined paternity index indicates how many times more likely the observed genetic evidence is if the alleged father is the true biological father of the tested child rather than an unrelated individual from each of the above populations."

What does all this mean?

Washington State DNA Testing Backlog

Stopping serial rapists with data

Since the SAFE* advisory group's conception, about 76% of the backlog has been sent to an outsourced laboratory, according to Denise Rodier, the technical lead forensic scientist at the Washington State Patrol Seattle Crime Laboratory. Orwall said the entire backlog is set to be tested by mid-2022.

* Sexual Assault Forensic Examination Best Practices Advisory Group, made up of legislators, law enforcement, lawyers, health care workers, advocates and survivors.

https://crosscut.com/politics/2021/04/wa-pushes-beyond-clearing-sexual-assault-evidence-kits

Forensic Genealogy

By Meagan Flynn
May 21, 2018

For the past 30 years, evidence found at the scenes of the killings of Jay Cook and Tanya Van Cuylenborg was mostly confined to a blue blanket wrapped around Cooks body, an abandoned bronze 1977 Ford Club Wagon and, crucially, the killer's DNA. The couple was from Saanich, British Columbia, and on the evening of Nov. 18, 1987, they were traveling in the Cook family van to Gensco Heating in Seattle to pick up a part for Cooks father. They were last seen purchasing a ticket around 10 p.m. in Bremerton, Wash., to board a ferry to Seattle, but they never made it there. Several days later, 18-year-old Van Cuylenborg's body was found partly clothed, dumped in a ditch in a wooded area in Skagit County, Wash. She had been raped.

www.washingtonpost.com/news/morning-mix/wp/2018/05/21/

Forensic Genealogy

But then investigators ran the DNA from the scene through a genealogy website. They turned up two second cousins of Talbott, which led them to him. And now they have charged Talbott, 55, with murder, saying his DNA profile found through his ancestors this month matches the DNA left at the crime scene 31 years ago. "It's the genetic genealogy that was the key tool that got this case resolved," Detective Jim Scharf of the Snohomish County Sheriffs Office, who sought the DNA technology and has spent 13 years studying this case, said at a Friday news conference. "Had law enforcement never had access to genetic genealogy, I don't think this case ever could have been solved." Talbott pleaded not guilty to the first-degree murder charges on Friday. He is charged only in Van Cuylenborg's death, but Scharf says he anticipates Talbott also being charged in Cook's. An attorney for Talbott could not immediately be reached for comment.

First Forensic Genealogy Conviction

"Man convicted in 1987 killing of young couple gets life sentence 3 decades later.

William Talbott II received two consecutive life terms for the 1987 killings of an 18-year-old woman and her 20-year-old boyfriend. "

Check out this story on courier-journal.com for July 14, 2019:

https://www.usatoday.com/story/news/nation/2019/07/24/william-talbott-ii-life-sentence-murder-van-cuylenborg-cook/1822503001/

HISTORY OF IDENTIFICATION

Legal v. Scientific Thinking

"The very goals of science and law differ. Science searches for the truth and seeks to increase knowledge by formulating and testing theories. Law seeks justice by resolving individual conflicts, although this search often coincides with one for truth."

"Rules of decision that are not tailored to individual cases, such as those that turn on statistical reasoning, are often viewed as suspect."

Feinberg SE (Editor). 199. *The Evolving Role of Statistical Assessments as Evidence in the Courts.* Springer.

Forensic Science Approach

"The central problem of the criminal investigator is the establishment of personal identity − usually of the criminal, sometimes of the victim."

Kirk PL. 1974. *Crime Investigation.*

Need to distinguish between identity and individualization. **Identity** refers to unique existence − no two different things can be identical. The DNA profiles from a suspect and a crime scene are different things.

Individualization points to a specific person. A fingerprint from a crime scene is not identical to a suspect's recorded fingerprint, but can be used to identify him and prove his individuality.

Uniqueness

"no two objects can ever be identical. They can and often do have properties that are not distinguishable. If enough of these properties exist … *identity of source* is established."

"The criminalist of the future may well be able to individualize the criminal directly through the hair he has dropped, the blood he has shed, or the semen he has deposited. All these things are unique to the individual, just as his fingerprints are unique to him."

Kirk PL. 1974. *Crime Investigation.*

Forensic science question

Not: ''Is this profile unique?'' (it is).

Not: ''Are these two profiles identical?'' (they can't be).

But: '' Is there sufficient evidence to demonstrate that these two profiles originate from the same source?''

Bertillonage

Alphonse Bertillon (1853-1914), French anthropometrist. Son and brother of statisticians. Used 11 measurements:

1.   Standing height
2.   Arm reach
3.   Sitting height
4.*   Head length
5.*   Head breadth
6.   Length of right ear
7.   Cheek width
8.*   Length of left foot
9.*   Length of left middle finger
10.   Length of left little finger
11.   Length of the left forearm and hand to the tip of extended middle finger

Bertillonage

Searching was done on four categories (numbers 4, 5, 8, 9). Each measurement divided into three subdivisions (large, medium, small) i.e. $3^4 = 81$ categories per person. Filing cabinets with 81 drawers used.

Using all 11 characters, plus 7 eye colors, the number of possible profiles is $3^{11} \times 7 = 1,240,029$.

Wikipedia entry for Alphonse Bertillon

"Being an orderly man, he was dissatisfied with the ad hoc methods used to identify the increasing number of captured criminals who had been arrested before. This, together with the steadily rising recidivism rate in France since 1870, motivated his invention of anthropometrics. His road to fame was a protracted and hard one, as he was forced to do his measurements in his spare time. He used the famous La Sant Prison in Paris for his activities, facing jeers from the prison inmates as well as police officers.

He is also the inventor of the mug shot. Photographing of criminals began in the 1840s only a few years after the invention of photography, but it was not until 1888 that Bertillon standardized the process."

https://en.wikipedia.org/wiki/Alphonse_Bertillon

Coincidental match

Two different men at Leavenworth in 1903 had very similar Bertillon dimensions (lengths in mm):

	Will West	William West
1	19.7	19.8
2	15.8	15.9
3	12.3	12.2
4	28.2	27.5
5	50.2	50.3
6	178.5	177.5
7	9.7	9.6
8	91.3	91.3
9	187.0	188.0
10	6.6	6.6
11	14.8	14.8

http://www.globalsecurity.org/security/systems/biometrics-history.htm

Fingerprints

"The arrangement of skin ridges is never duplicated in two persons."
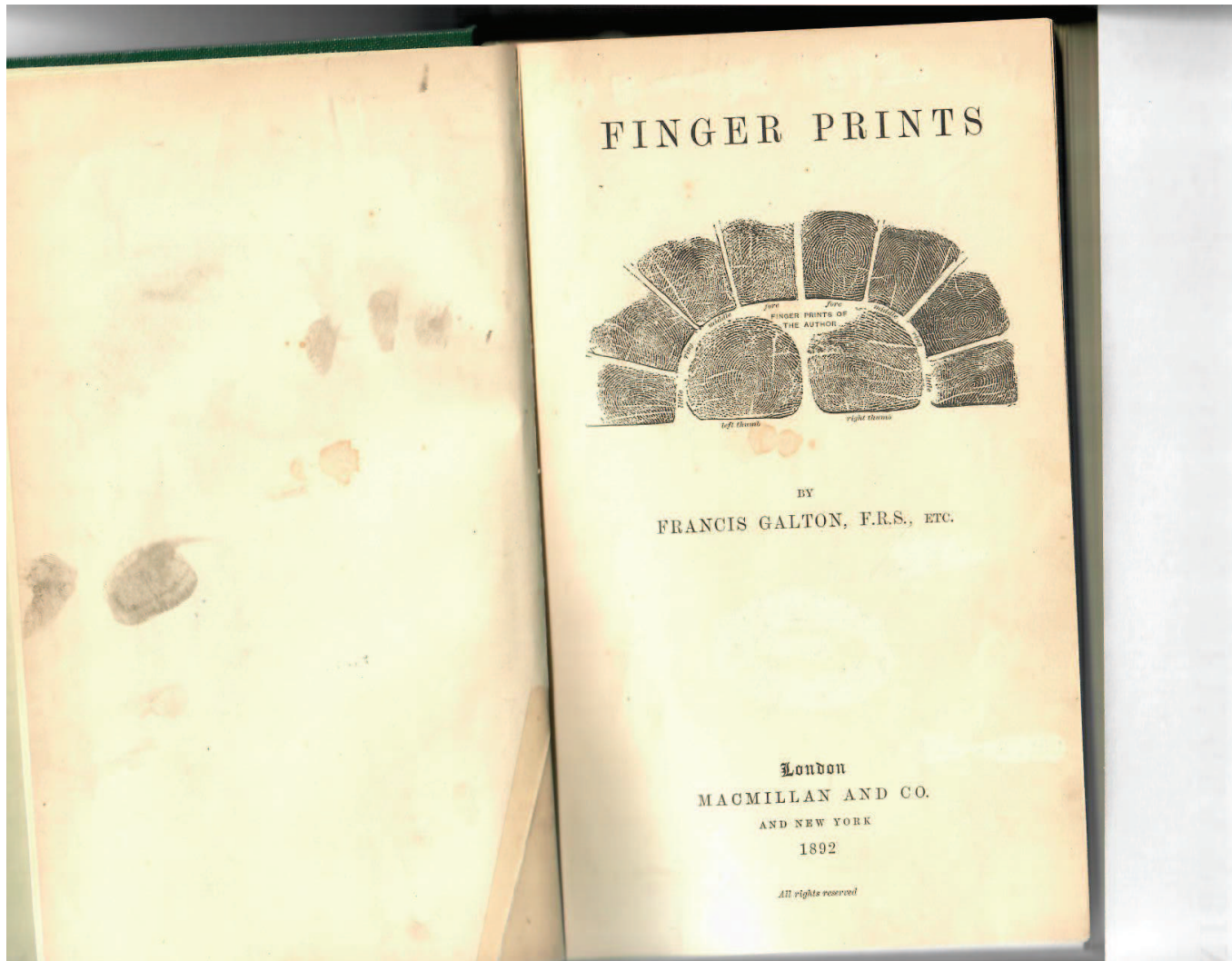J.C.A. Mayer, 1783.

J.E. Purkinje established categories of fingerprints in early 19th century.

W. Herschel, a British administrator, used fingerprints in India in 1850's.

H. Faulds, a British physician, used fingerprints in Japan.

Francis Galton wrote the book "Fingerprints" in 1892, and gave some probabilities for coincidental matches.

Francis Galton, 1892

FINGER PRINTS

FINGER PRINTS OF THE AUTHOR

left thumb   right thumb

BY

FRANCIS GALTON, F.R.S., ETC.

London
MACMILLAN AND CO.
AND NEW YORK
1892

Fingerprints

Galton considered that the chance that a random fingerprint could match a specified print was 1 in 2^{36} (about 1 in 69 trillion).

For a population of size 1.6 billion, the odds were 1 to 39 that the print of any single finger would be exactly like the same finger of any other person.

[This is based on the probability of not finding the print in a sample of size 1.6 billion.]

Heritability of fingerprints

Galton looked at 105 sib-pairs:

Second	First sib			
sib	Arches	Loops	Whorls	Total
Arches	**5**	12	2	19
Loops	4	**42**	15	61
Whorls	1	14	**10**	25
Total	10	68	27	105

Galton noticed that the diagonal counts of 5, 42, 10 are larger than those (2, 40, 6) expected if the sibs had independent fingerprints, but not as great as they could be (10, 61, 25). He did not have the chi-square test available in 1892, but did conclude that there was an association.

He did not find racial differences.

Uniqueness of fingerprints

Probability arguments not currently used. By 1924, textbooks would say "No two fingerprints are identical in pattern." In 1939 J.Edgar Hoover wrote that fingerprints were "a certain and quick means of identification."

Acceptance of uniqueness probably followed from "(i) striking visual appearance of fingerprints in court, (ii) a few dramatically successful cases, and (iii) a long period in which they were used without a single case being noted where two different individuals exhibited the same pattern."

Stigler SM. 1995. Galton and identification by fingerprints. Genetics 140:857-860.

Stigler anticipated the same growing acceptance of DNA profiles being unique.

Misuse of Fingerprints

Oregon attorney Brandon Mayfield was wrongly identified by the FBI as the source of a fingerprint on an item of evidence in the 2004 Madrid train bombings.

https://en.wikipedia.org/wiki/Brandon_Mayfield

A subsequent report by the FBI admitted the error

https://www.fbi.gov/about-us/lab/forensic-science-communications /fsc/jan2005/special_report/2005_special_report.htm

although it did not state that Mayfield had been arrested.

Accuracy of Fingerprints

A subsequent study "Accuracy and reliability of forensic latent fingerprint decisions" was published

"169 latent print examiners each compared approximately 100 pairs of latent and exemplar fingerprints from a pool of 744 pairs. ...Five examiners made false positive errors for an overall false positive rate of 0.1%. Eighty-five percent of examiners made at least one false negative error for an overall false negative rate of 7.5%."

Ulery BT, et al. 2011. Proc Natl Acad Sci USA 108:7733-7738.

Statistical approach

Partial transfer evidence: physical material or impressions transferred from crime scene to perpetrator (or perpetrator's possessions), or vice versa.

PTE is characterized and assigned to an identity-set. Does a particular person (or their type) belong to the set? Does anyone else belong to the set?

"If it is *highly improbable* that another member could be found, we would be *reasonably sure* that the correct origin has been located. But if it is *quite probable* that other members exist, we would *not be so sure* that we have the correct origin."

Kingston CR. 1965. J Am Stat Assoc 60:70-80, 1028-1034.

Blood Typing

Human ABO blood groups discovered in 1900. ABO gene on human chromosome 9 has 3 alleles: A, B, O. Six genotypes but only four phenotypes (blood groups):

Genotypes	Phenotype
AA, AO	A
BB, BO	B
AB	AB
OO	O

ABO System

The possible offspring blood groups for each pair of parents:

Father	Mother			
	A	B	AB	O
A	A,O	A,B,AB,O	A,B,AB	A,O
B	A,B,AB,O	B,O	A,B,AB	B,O
AB	A,B,AB	A,B,AB	A,B,AB	A,B
O	A,O	B,O	A,B	O

ABO System

For blood transfusions, recipient should not produce antibodies to the donor's antigens:

Recipient (Antibody)	Donor (Antigen)			
	O (None)	A (A)	B (B)	AB (A & B)
O (Anti-A & Anti-B)	OK			
A (Anti-B)	OK	OK		
B (Anti-A)	OK		OK	
AB (None)	OK	OK	OK	OK

https://www.ncbi.nlm.nih.gov/books/NBK2267/

Charlie Chaplin and ABO Testing

Relationship	Person	Blood Group	Genotype
Mother	Joan Berry	A	AA or AO
Child	Carol Ann Berry	B	BB or BO
Alleged Father	Charles Chaplin	O	OO

The obligate paternal allele was B, so the true father must have been of blood group B or AB.

Berry v. Chaplin, 74 Cal. App. 2d 652

California Court of Appeals, 1946

"Concerning the immutability of the scientific law of blood-grouping, which we have no reason to question …"

"Whatever claims the medical profession may make for blood tests to determine paternity, no evidence is by law made conclusive or unanswerable unless so declared by the Code of Civil Procedure of the State of California "

74 Cal.App.2d 652 (1946)

Outcome of Chaplin Trial

"The brouhaha surrounding Chaplin's case and similar paternity suits (like 1937's Arais v. Kalensnikoff and 1951's Hill v. Johnson) led to the reformation of paternity laws in the state of California, with other states eventually following suit. In 1953, along with Oregon and New Hampshire, California drafted the Uniform Act on Blood Tests to Determine Paternity, which in legalese states that: 'If the court finds that the conclusions of all the experts as disclosed by the evidence based upon the tests are that the alleged father is not the father of the child, the question of paternity shall be resolved accordingly.' "

http://mentalfloss.com/article/63158/how-charlie-chaplin-changed-paternity-laws-america

Spencer v Commonwealth of Virginia

From the Supreme Court of Virginia, September 22, 1989.

"Timothy Wilson Spencer was indicted for the capital murder of Susan Tucker, i.e., the willful, deliberate, and premeditated murder during the commission of, or subsequent to, rape. Spencer also was indicted for the rape of Tucker. ... a jury convicted Spencer of capital murder and fixed his punishment at death. The jury also convicted Spencer of rape and fixed his punishment at life imprisonment. Following a sentencing hearing, the trial court imposed the sentences fixed by the jury and entered judgments on the jury verdicts.

... We have considered all of Spencer's assignments of error and find no reversible error. We also have made the review of the death sentence mandated by Code 17-110.1 and conclude that the sentence should be affirmed. Accordingly, the judgments of the trial court will be affirmed."

Spencer v Commonwealth of Virginia (contd.)

"The parties stipulated that Spencer does not have an identical twin and that none of his blood relatives had committed the murder. Therefore, the chances that anyone other than Spencer produced the semen stains was one in 135 million. There are approximately 10 million adult black males in the United States."

SPENCER v. COM 384 S.E.2d 775 (Va. 1989)

aw.justia.com/cases/virginia/supreme-court/1989/890579-1.html

Spencer was the first person executed after a conviction based on DNA evidence. Virginia outlawed the death penalty on March 24, 2021.

Extreme Numbers: Robinson v. Mandell, 1868.

Two signatures matched at 30 downstrokes. The probability of a coincidental match was estimated to be 1 in 5. The probability of 30 coincidences in one pair of signatures was "once in 2,666 millions of millions of millions." (Mathematics professor Benjamin Pierce.)

"This number far transcends human experience. So vast an improbability is practically an impossibility. Such evanescent shadows of probability cannot belong to actual life. They are unimaginably less than those least things which the law cares not for."

Refers to chance of a coincidental match between two handwriting samples.

https://en.wikipedia.org/wiki/Howland_will_forgery_trial

No Extreme Numbers in Minnesota

"Schwartz contends that any probative value of statistical frequency evidence is outweighed by its prejudicial effect, as illustrated by the media exposure forensic DNA typing has received implying its infallibility. In dealing with complex technology, like DNA testing, we remain convinced that juries in criminal cases may give undue weight and deference to presented statistical evidence and are reluctant to take that risk."

447 N.W.2d 422 (1989)

Refers to matching DNA profile with a frequency reported as 1 in 33 billion.

DNA Profiling

Human Genome has about 3,000,000,000 elements (base pairs).

Any two people differ at about 3,000,000 of these.

Forensic profiles in the US use 20 "CODIS" features of the genome. Each of these "markers" has at least 10 variant forms, or at least 55 different combinations. Therefore there are about 55^{20} or 6.4×10^{34} different profiles possible.

There are less than 8 billion (8×10^9 people in the world. Even if they all had different CODIS profiles, only 1 in 8×10^{24} of the possible profiles exists in the whole world. The chance of winning the Powerball lottery is about 1 in 3×10^8.

Beyond Reasonable Doubt?

After forensic evidence is presented, a jury or judge may have to make a decision, based on the concept of "beyond reasonable doubt." What does that mean? A survey found:

Probability	Judges	Jurors	Students
0–50%	0	5	3
50%	1	6	2
55%	2	2	1
60%	8	4	1
65%	2	1	0
70%	14	2	1
75%	23	2	1
80%	58	8	9
85%	21	2	3
90%	68	9	20
95%	44	3	17
100%	106	25	30
Total	347	69	88

People v. Collins

Another attempt to introduce probabilities into court:

Characteristic	Frequency
Girl with blond hair	1 in 3
Girl with ponytail	1 in 10
Man with mustache	1 in 4
Black man with beard	1 in 10
Yellow car	1 in 10
Interracial couple in car	1 in 1000
All six characteristics	1 in 12 million

https://en.wikipedia.org/wiki/People_v._Collins

People v. Collins

Janet and Malcolm Collins were convicted of second-degree robbery in late November, 1964, seemingly based on the mathematical calculation in the absence of any hard evidence. Malcolm appealed his conviction, eventually leading to the judgment being reversed. By that time, Janet had already served her full sentence.

People v. Collins

The California Supreme Court emphasized that there was no objection to the use of mathematics in court in itself, but concluded that the application to this case was seriously flawed.

1. There was no evidence provided as to how the probabilities as used in the testimony were inferred.

2. There was no proof as to whether the selected characteristics were independent.

3. The perpetrators may not have possessed the six characteristics, because they were disguised or the eyewitness testimonies were inaccurate.

4. The prosecutor urged the jury to equate the probability of the evidence to the probability that the defendants were innocent.

People v. Collins

"As we explain in detail, infra, the testimony as to mathematical probability infected the case with fatal error and distorted the jury's traditional role of determining guilt or innocence according to long- settled rules. Mathematics, a veritable sorcerer in our computerized society, while assisting the trier of fact in the search for truth, must not cast a spell over him. We conclude that on the record before us defendant should not have had his guilt determined by the odds and that he is entitled to a new trial. We reverse the judgment."

https://law.justia.com/cases/california/supreme-court/3d/1/658.html

People v. Collins

Based on the four grounds above, the use of mathematics in this particular case was deemed inadmissible and the original judgment was reversed. As mentioned, the Court stressed that the dismissal did not imply a disapproval or disparagement of mathematics as a tool in trials.

Significantly, in its appendix, the Court even went as far as to providing an alternative analysis. Although this analysis has been criticized in responses to the Court's memo, it marked the beginning of the acceptance of probabilities into legal discussions.

https://law.justia.com/cases/california/supreme-court/3d/1/658.html