DNA & Crime:
An Introduction Into
Forensic Genetic Genealogy.

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SECTION 1:

Forensic Genetic Genealogy.

What is Forensic Genetic Genealogy?

Forensic Genetic Genealogy, also known as Investigative Genetic Genealogy and referred to outwith as FGG, is an emerging form of forensic investigation that utilises "a biological sample from a crime scene or from human remains [… which is then…] genotyped using a set of single-nucleotide polymorphisms (SNPs)"[1] which, when analysed against a database of deoxyribonucleic acid (DNA) profiles allows investigators to generate a list of possible genetic familial matches.

This process is based on the fundamental understanding that DNA - in the simplest form - is a polymer (substance made from multiple repeating macromolecular monomers) constructed from nucleotides. A nucleotide is a molecule composed of a nitrogen base, a five-carbon monosaccharide (an organic simple sugar, either Deoxyribose to form DNA, or Ribose to form RNA) and a phosphate. These nucleotides code for the genotype (the genetic traits of an organism) and the phenotype (the observable traits of an organism). Nucleotides may undergo a number of processes (ranging from random mutations to deliberate editing) which may present a polymorphic effect (that is, of multiple forms) whereby a single nucleotide is substituted for another within a specific position of the genome (locus). This results in a Single Nucleotide Polymorphism (SNP) which is inheritable and may pass down, allowing for Forensic Genetic Genealogy where these mutations are analysed and a family tree is mapped out.

The databases used to generate these possible genetic matches is generally Direct-to-Consumer (DTC) in form, such as GEDmatch (boasting over two million genetic profiles, over the last fifteen years)[2] and FamilyTreeDNA, both of which permit law enforcement to access the databases[3,4]. As FGG is unregulated and its legality in many jurisdictions is under question, it has mainly been conducted within North America, with some examples in Scandinavia[5] and other such places. Furthermore, the physical process of SNP analysis is

[1] Ertürk, M.S., Fitzpatrick, C., Press, M. and Wein, L.M. (2022). Analysis of the genealogy process in forensic genetic genealogy. Journal of Forensic Sciences, 67(6). doi:https://doi.org/10.1111/1556-4029.15127.

[2] GEDmatch (2024). Analyze Your DNA. [online] GEDmatch. Available at: https://www.gedmatch.com [Accessed 3 Nov. 2025].

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[4] FamilyTreeDNA (2025). FamilyTreeDNA Law Enforcement Guide. [online] Familytreedna.com. Available at: https://www.familytreedna.com/legal/law-enforcement-guide?srsltid=AfmBOoqT9xi6goqxRN6xV9eSxli2lb0D3tdYCywHyB5zoNzjKg8t-lsY [Accessed 3 Nov. 2025].

[5] King, T. and The Royal Institute (2023). Investigative genetic genealogy. [online] Royal Institution. Available at: https://www.rigb.org/explore-science/explore/video/investigative-genetic-genealogy-turi-king [Accessed 3 Nov. 2025].

almost always outsourced to 3rd party laboratories[6] such as Parabon NanoLabs[7]. FGG has been used to identify Jane and John Does (a term used to name an unidentified person), alongside suspected criminals, allowing for the resurrection of so called 'cold cases' where the investigation has since no other active leads.

While some have traced the idea behind FGG as as far back as 2010[8], it is still a very young investigatory method. In fact, though Forensic Genetic Genealogy shares a similar name to the more traditional method of familial searching, it differs dramatically in both theory and practise. Unlike FGG, Familial searching works by utilising Short Tandem Repeats (STR) and allows law enforcement, if there is no direct hit on national DNA databases (such as the Combined DNA Index System, CODIS)[9] to "conduct an independent search to identify potential relatives of the alleged perpetrator."[10] CODIS, which is maintained by the Federal Bureau of Investigation (FBI), is the the United State's paramount National DNA Database connecting all of the individual statewide offender databases.

Short Tandem Repeats are a form of allelic repeats (a variant of the sequence of nucleotides) at loci (a fixed position on a chromosome where a specific gene is located) within the genome. STRs occur with repeat units ranging from 2 to 7 base pairs in length, for example, an STR sequence may showcase as 4 repeats of ATCG within the genome, presenting as {ATCG/ATCG/ATCG/ATCG}, where ATCG are notations of base pairs; Adenine and Thymine, Cytosine and Guanine. It is important to note that unlike SNP, every individual has this marker at the same locus on their chromosome, however the amount of repeats the unit has within the sequence varies greatly from person to person. This is key as an individual may inherit, say 4 repeats on the locus from parent A and 6 repeats on the locus from parent B, resulting in a relatively unique profile of {4,6}.

Furthermore the method of analysing the short tandem repeats is vastly different from FGG, whereby the DNA sequence is amplified via a Polymerase Chain Reaction (PCR - the

[6] Biospace (2016). Parabon NanoLabs Awarded U.S. Department Of Defense (DoD) Contract To Aid Identification Of Unknown Remains From Past Conflicts. [online] BioSpace. Available at: https://www.biospace.com/parabon-nanolabs-awarded-b-u-s-department-of-defense-dod-b-contract-to-aid-identification-of-unknown-remains-from-past-conflicts [Accessed 6 Nov. 2025].

[7] Parabon Nanolabs (2025). Parabon NanoLabs: Engineering DNA for Next-Generation Therapeutics and Forensics. [online] parabon-nanolabs.com. Available at: https://parabon-nanolabs.com [Accessed 6 Nov. 2025].

[8] The DNA Geek (2019). Timeline of Forensic Genetic Genealogy. [online] The DNA Geek. Available at: https://thednageek.com/timeline-of-investigative-genetic-genealogy/ [Accessed 3 Nov. 2025].

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[10] Vordtriede, C. (2023). Vulnerable Fraudsters: Reverse Affinity Fraud in Cases of Public Hoaxes. Criminal Law Practitioner, [online] 14(1). Available at: https://digitalcommons.wcl.american.edu/clp/vol14/iss1/2/. [Accessed 5 Nov. 2025].

use of the enzyme DNA Polymerase and temperature cycling to denature, anneal and extend the DNA in order to exponentially grow the number of nucleotides within a sample) and the resulting DNA fragments are then separated via capillary electrophoresis (the process of passing “fluorescently labelled DNA strands through very thin polymer filled capillaries in order to exert enterokinetic forces onto the fragments and detect the fragments via the use of lasers onto the fluorescent labelled which are then Spectro-analysed”), generating a electropherogram. This electropherogram allows the analyst to read the STR data in the form of a numeric profile. The STR profile is then uploaded to a DNA database, such as the aforementioned CODIS and the British National DNA Database (NDNAD), and since the probability of two unrelated candidates sharing the same STR profile is astronomically low, STR analysis remains a key method in identifying individuals.

When would it be appropriate to employ Forensic Genetic Genealogy?

It is usually the case that both SNP and STR analysis goes hand in hand. This is due to the fact that while STR analysis is very helpful in identifying the individual against a national DNA database, it is not as useful when there is no direct DNA to match against. However, as the name "familial searching" implies, STR analysis can be used to confirm the connection of two people due to the fact that while the probability of two unrelated candidates sharing the same STR profile is very unlikely, genetic inheritance suggests that those who share 1st degree relations (such as maternal, paternal, and full sibling relations) will share DNA.

This is where the joint venture of FGG and Familial Searching comes together, to allow for the identification of Jane and John Doe's. If there is an unidentified body, Law Enforcement Agencies (LEAs) can first preform STR analysis to see if there is any perfect or 1st degree hits on the national database. If there are no leads LEAs could use, they could implement FGG testing to see if there are any partial hits on open source or DTC databases, allowing for a mapping of a family tree. If there are any living and willing hits, LEAs could then perform STR testing once again to confirm a 1st degree match to the Jane/John Doe. Although not much is known about the investigation into the murder of many Jane Does, two key case studies that stand out in the analysis of the applications of FGG would be the investigation into the "Golden State Killer" and the murder of the "Buckskin Girl".

2018 saw the first case in which FGG was used as a scientific investigative method in (and of) its own right, with the investigation into Joseph James DeAngelo Jr, also known as "The Golden State Killer" (GSK) and "The East Area Rapist/Original Night Stalker" (EARONS). Born in 1945, DeAngelo had murdered his 1st victim, Claude Snelling, in 1975 and his 13th and final confirmed kill, 18-year-old Janelle Cruz of Irvine 11 years later[11]. During this time, he had gone on a spree of child molestation, rape, and sexually assaulting the woman who he'd kidnap[12]. His victims and their families did not see the justice they deserved until 2018.

Despite DNA making its debut in the Colin Pitchfork case three decades prior[13], investigators had reached a permanent roadblock using traditional methods. The STR profile, generated from the evidence and uploaded to the national CODIS database, produced neither

[11] Stanton, S. (2025). Sacramento DA reveals push to convict Golden State Killer: 'Never stopped searching'. [online] Sacramento Bee. Available at: https://www.sacbee.com/news/local/article312773814.html [Accessed 6 Nov. 2025].

[12] Genealogy Explained (2023). Joseph DeAngelo. [online] www.genealogyexplained.com. Available at: https://www.genealogyexplained.com/igg-cases/joseph-deangelo/ [Accessed 5 Nov. 2025].

[13] Patel, A. (2023). When was the first criminal caught using DNA evidence? - The Tech Interactive. [online] Thetech.org. Available at: https://www.thetech.org/ask-a-geneticist/articles/2023/first-criminal-caught-using-dna-evidence/ [Accessed 6 Nov. 2025].

a direct match to an offender nor a close familial match leading law enforcement to pivoted towards FGG. The crime scene sample was sent to a private lab for SNP genotyping, creating a far more comprehensive genetic profile, which was subsequently uploaded to GEDmatch. The system immediately returned partial hits to several distant relatives of the GSK. From this lead, genealogical specialists built extensive family trees to trace the possible lineage of the unknown subject, eventually - with the help of his victims who described the GSK as "a 5'9", 165-pound, white male"[14] - identifying Joseph DeAngelo as a prime suspect.

The final and most crucial stage involved the complementary use of STR analysis. Following the FGG lead, investigators covertly collected DNA from a discarded tissue[15] and an STR profile was generated from this sample, which was then compared directly against the original STR profile collected from the crime scenes. Only when these two STR profiles resulted in a perfect match could the forensic evidence be presented in court, confirming the FGG-generated lead. The successful prosecution of the Golden State Killer demonstrated that FGG is a powerful tool for generating leads, but like all forms of forensic science, it must always be validated by other sources. While the GSK case was the first and the most prolific case of FGG, it has not been the last.

The identification of the murdered Marcia King (1959-1981), previously unknown as the Buckskin Girl of Co. Miami, Ohio (USA), was a pivotal moment in the advancements of FGG. King, who was an avid hiker[16], was found dead after going missing. Found by Greg Bridenbaugh and Neal Hoffman[17], Marcia King was wearing a distinctive buckskin jacket which tested positive for pollen from over 1,000 miles away near the southern border which allowed people to question the nature of her death. Marcia King was identified via the use of her a "unrefrigerated heparinised, ("the process of using heparin, an anticoagulant, in medical procedures to prevent blood clotting"[18]), blood sample from 1982"[19] which allowed for the re-opening of the previously cold case. In the early 2000's Marcia King's blood was analysed

[14] Chamary, J.V. (2020). How Genetic Genealogy Helped Catch The Golden State Killer. [online] Forbes. Available at: https://www.forbes.com/sites/jvchamary/2020/06/30/genetic-genealogy-golden-state-killer/ [Accessed 6 Nov. 2025].

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[17] She goes by Jane (2023). Marcia Sossoman King/Buckskin Girl. [online] YouTube. Available at: https://www.youtube.com/watch?v=123J2Xi-G30 [Accessed 5 Nov. 2025].

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[19] CBS News (2018). New DNA tech ID's 1981 murder victim known as 'Buckskin Girl'. [online] YouTube. Available at: https://www.youtube.com/watch?v=jSKM4EUGozw [Accessed 4 Nov. 2025].

allowing for a DNA profile to be built. In 2008, that profile was uploaded to the National Missing and Unidentified Persons System (NamUs)[20] and in 2009, mitochondrial DNA (mtDNA) from the victim was submitted to CODIS. Though Marcia King was not a minor at the time of her death, the National Centre for Missing & Exploited Children (NCMEC) was involved in the release of multiple forensic facial reconstructions which ultimately lead to another dead end as no new leads emerged.

The breakthrough finally came in April of 2018 after investigators partnered with the DNA Doe Project, a non-profit specialising in FGG, had sent the 1982 heparinised blood sample to a private lab which then allowed for upload to DTC and Open-Source DNA databases. Genealogists then used this match to construct a family tree, ultimately leading them to King's family and the positive identification of the "Buckskin Girl" after nearly 37 years. Marcia King's identity was finally confirmed via Familial Searching from a 1st degree relative. Beyond this point, there has not been much information as the family of Marcia King has always requested privacy over this travesty[21] and for that reason I will not go beyond the forensic investigations.

[20] U.S. Department of Justice (2024). What is NamUs? | NamUs. [online] namus.nij.ojp.gov. Available at: https://namus.nij.ojp.gov/what-namus [Accessed 4 Nov. 2025].

[21] Farberov, S. (2018). Body found in Ohio in 1981 identified as Arkansas woman. [online] Mail Online. Available at: https://www.dailymail.co.uk/news/article-5607573/Body-Ohio-1981-identified-Arkansas-woman.html [Accessed 5 Nov. 2025].

What technical challenges are posed by Forensic Genetic Genealogy?

Forensic Genetic Genealogy is not a form of magic, allowing for cold cases to be mystically solved, physical limitations do exist. DNA degradation and sample quality are two of the biggest limitations when it comes to any form of forensic science. While DNA is notoriously difficult to destroy completely, surviving temperatures well in excess of 800°C [22] it is reasonably easy to degrade beyond effective reading, and begins to denature as low as 190°C[23]. This creates issues with forensic investigations relating to DNA as many criminals may attempt to scorch or burn evidence. The more extreme of environments the evidence endures, the lower the quantity of high-quality DNA can be extracted from that evidence, however some DNA may be extracted.

Another key technical factor to consider is the massive amounts of data (id est, SNPs) that must be analysed by the aforementioned 3rd party labs. It is theorised that all the data from the human genome could be condensed into a file the size of 800 Megabytes, however in actuality "in order to sequence a whole human genome, you need to generate a bunch of short "reads" (~100 base pairs, depending on the platform) and then "align" them to the reference genome"[24] increasing the file size to over 200 Gigabytes per person. As these cutting-edge labs must process such a high read count, the time it takes to analyse SNPs and then create actionable intelligence can take weeks of precious time, especially in the cases of Jane/John Does, and unknown criminals.

Physical and Technical issues are not the only complexities present in the question of Forensic Genetic Genealogy. As with all forensic investigations by LEAs, there comes into question the legislative and moral codes by which investigators must work. The questions of "the privacy intrusion, misuse of the genomic data, and the misuse of the consent given by the volunteers"[25] that inherently comes with the field of any form of forensic investigation is only amplified with Forensic Genetic Genealogy as the field is too young to have been effectively controlled and legislated. In a world where state surveillance is becoming a

[22] Imaizumi, K. (2015). Forensic investigation of burnt human remains. [online] Research and Reports in Forensic Medical Science. Available at: https://www.dovepress.com/forensic-investigation-of-burnt-human-remains-peer-reviewed-fulltext-article-RRFMS [Accessed 6 Nov. 2025].

[23] Karni, M., Zidon, D., Polak, P., Zalevsky, Z. and Shefi, O. (2013). Thermal Degradation of DNA. DNA and Cell Biology, [online] 32(6), pp.298–301. doi:https://doi.org/10.1089/dna.2013.2056.

[24] Dr Robison, R.J. (2016). How big is the human genome? [online] Medium. Available at: https://medium.com/precision-medicine/how-big-is-the-human-genome-e90caa3409b0.

[25] Hirak Ranjan Dash, Elkins, K.M. and Noora Rashid Al-Snan (2023). Next Generation Sequencing (NGS) Technology in DNA Analysis. [online] Elsevier. Available at: https://www.sciencedirect.com/science/chapter/edited-volume/abs/pii/B978032399144500007X [Accessed 6 Nov. 2025].

norm[26, 27], the last two decades have showcased the theoretical reality of implementing voluntary, and in some cases, mandatory DNA profiles for criminals and citizens alike [28].

In 2015, the State of Kuwait announced its plans to fight religious extremism with mandatory DNA collection for all residents. The plan stated that "all 1.3 million citizens and 2.9 million foreign residents" have their DNA tested and placed into a database"[29]. However, this law did not last long as it was repealed in 2017[30]. Kuwait was not the only nation that wished to compile such a database, The Emirate of Dubai (Within the United Arab Emirates) had plans to compile a genetic database with the motive of "preventing genetic diseases"[31], however many mentioned the possibility of the government misusing these DNA samples for the purposes of tracking its population. By far the largest National DNA database collection effort was made by the People's Republic of China. With nearing on 100 million samples, many people have their eyes on the western Chinese provinces of Xizang (Tibetan) Autonomous Region and the Xinjiang Uygur Autonomous Region as human rights issues continue to grow in the region and forced DNA samples may be used in controlling citizens[32].

Overall, Forensic Genetic Genealogy is an emerging forensic investigative tool, that enables Law Enforcement Agencies, alongside members of the public, to search and find unidentified persons via searching for specific Single Nucleotide Polymorphic variations on Open Source and Direct to Consumer DNA databases. While it still may have its challenges, both legal and technical, from Identifying Jane and John Does to allowing the capture of wanted criminals (such as the golden state killer), FGG provides a promising and tested pathway - especially when pared with more traditional forms of investigatory tools (such as Short Tandem Repeat based DNA Identification).

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[26] Whannel, K. (2025). Government expands police use of live facial recognition vans. BBC News. [online] 13 Aug. Available at: https://www.bbc.co.uk/news/articles/cj4wy21dwkwo [Accessed 6 Nov. 2025].

[27] Fight Chat Control (2025). Protect Digital Privacy in the EU. [online] Fightchatcontrol.eu. Available at: https://fightchatcontrol.eu [Accessed 6 Nov. 2025].

[28] BBC (2007). All UK 'must be on DNA database'. news.bbc.co.uk. [online] 5 Sep. Available at: http://news.bbc.co.uk/1/hi/uk/6979138.stm [Accessed 6 Nov. 2025].

[29] Visser, N. (2015). Kuwait To Institute Mandatory DNA Testing For All Residents. [online] HuffPost. Available at: https://www.huffpost.com/entry/kuwait-mandatory-dna_n_7795442 [Accessed 6 Nov. 2025].

[30] Human Rights Watch (2017). Kuwait: Court Strikes Down Draconian DNA Law. [online] Human Rights Watch. Available at: https://www.hrw.org/news/2017/10/17/kuwait-court-strikes-down-draconian-dna-law [Accessed 6 Nov. 2025].

[31] Trevino, J. (2018). Dubai Wants to DNA Test Its Millions of Residents to Prevent Genetic Disease. [online] Smithsonian Magazine. Available at: https://www.smithsonianmag.com/smart-news/dubai-wants-dna-test-all-its-residents-prevent-diseases-they-happen-180968314/ [Accessed 6 Nov. 2025].

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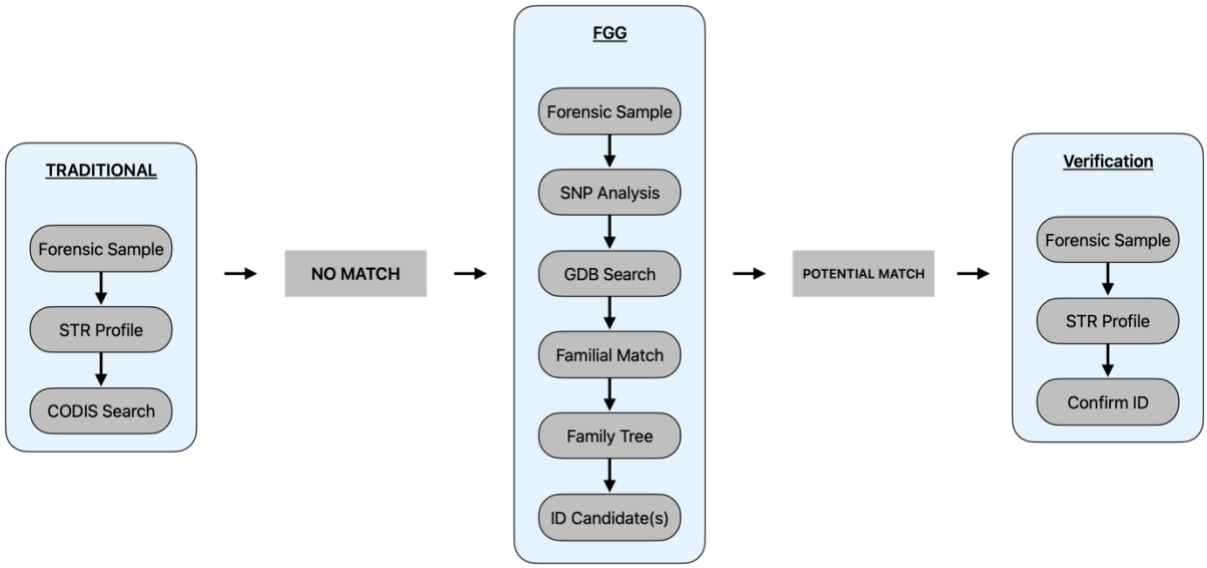
SECTION 2:

Annex and Accreditation.

Annex A



Annex A is a diagram showcasing the pathway of completing a Short Tandem Repeat based 'Traditional' approach to familial searching, followed by Forensic Genetic Genealogy, and finally confirmation of ID via STR testing. This is in particular relevant to both case studies within the subsection "Applications of Forensic Genetic Genealogy".

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