



Forensic Genetic Genealogy Laboratory Considerations and Technology Limitations

Introduction

The application of forensic genetic genealogy (FGG) has proven to be a powerful investigative tool for resolving cold case violent crimes. The technology came to the forefront of the forensic community's attention in 2018 when it led to the arrest of Joseph James DeAngelo, otherwise known as the Golden State Killer, who had eluded law enforcement for decades. He was brought to justice by this novel technique, which combines traditional genealogy research with DNA analysis in an effort to generate investigative leads for criminal investigations.¹

Since 2018, the DNA technologies associated with FGG have rapidly evolved, providing increased opportunities to resolve cases—even those previously thought to be unresolvable. Despite its proven success, the application of FGG does have technological limitations and will not resolve every case. By taking the time to thoroughly vet cases and associated evidence with both local crime laboratory representatives and FGG vendor laboratory representatives, as well as other multidisciplinary team (MDT) members, law enforcement investigators can greatly increase the chances of attaining successful case resolutions with FGG.

Law enforcement is highly encouraged to discuss potential case candidates with their MDT before proceeding with submission of evidence. Input from local crime laboratory representatives and the chosen FGG vendor laboratory can aid the MDT in determining if a sample is sufficient for processing and has the highest likelihood of returning sufficient data compatible with relevant genealogy databases.

Evolving Technologies

The FGG process begins by submitting forensic DNA evidence from an unknown perpetrator or victim to a private DNA vendor laboratory. FGG data are derived from single nucleotide polymorphism (SNP)-based DNA testing, which provides more genetic information than a traditional short tandem repeat (STR) profile that is uploaded into the FBI's Combined DNA Index System (CODIS). The most common SNP-based technologies currently used to develop data sufficient for FGG analysis are SNP Microarray and Whole Genome Sequencing (WGS). Most local and state crime laboratories produce STR profiles, but at present, SNP Microarray and WGS must be completed by private DNA vendor laboratories.² Since 2018, the capabilities of these vendors have rapidly improved, affording law enforcement investigators additional opportunities to resolve violent cold case crimes. With recent advancements in DNA techniques and technologies, vendor laboratories require less DNA for processing, can obtain informative results from degraded samples with high levels of bacterial contamination, and can successfully separate samples containing DNA from more than one individual. ***Despite these advancements, there are still limitations to FGG technology, and not every case or evidentiary item is an ideal candidate for FGG.***

¹ Emily Shapiro, October 30, 2020, "The 'Golden State Killer': Inside the Timeline of Crimes," *ABC News*, <https://abcnews.go.com/US/inside-timeline-crimes-golden-state-killer/story?id=54744307>.

² U.S. Department of Justice, September 2019, *Interim Policy: Forensic Genetic Genealogical DNA Analysis and Searching*, Washington, DC, retrieved September 12, 2022, from <https://www.justice.gov/olp/page/file/1204386/download>.

Table 1 provides an overview of current submission criteria and general guidelines for FGG vendor laboratories. Before submitting a case for FGG analysis, in addition to ensuring that the case meets submission criteria set forth by the [U.S. Department of Justice Interim Policy on FGG](#),³ law enforcement investigators are encouraged to discuss the criteria outlined in Table 1 with their local crime laboratory representatives to determine whether the evidence has a high likelihood of returning usable results. Once a sample has been identified as a candidate for submission, further discussion with the vendor laboratory representatives is strongly recommended to ensure that the case and associated evidence meet their specific submission criteria, because not every laboratory has equal capabilities.

Table 1. Overview of FGG Vendor Laboratories' Forensic Evidence Submission Criteria

Accepted Quantities	Accepted Degradation Levels	Accepted Human DNA: Bacterial Contamination Ratios	Accepted Mixture Ratios
Considers how much human DNA within a sample is needed for analysis. This is often measured in nanograms (ng).	Considers the quality of the DNA (i.e., how degraded or contaminated a sample is). This can be measured by the degradation index (DI).	Considers how much human DNA is present in the sample compared to non-human DNA or bacterial contamination.	Considers how much DNA an individual contributes to a sample containing DNA from more than one individual.
FGG vendor laboratories routinely report successes with quantities between 1 ng and 20 ng ; however, successful profiles have been developed with as little as 0.12 ng. Submission criteria vary among vendor laboratories and sample types. For example, vendors may require higher quantities of human DNA for bone samples than blood samples.	FGG vendor laboratories have reported successes with DIs between 0.1 and 148 . The DI rating scale will vary depending on the type of technology used. Therefore, vendors typically do not have submission criteria related to the DI; rather, the vendor will assess the DI to determine the most appropriate SNP-based technology to apply to the sample.	FGG vendor laboratories have reported successes with less than 1% of human DNA, if the total amount of DNA is not limiting (see column 1). Vendors typically do not have submission criteria related to non-human DNA or bacterial contamination; instead, the vendor will assess the ratio to determine the most appropriate SNP-based technology to apply to the sample.	FGG laboratories have reported successes with samples containing DNA from 2 individuals . The unknown suspect or victim must be the major contributor (i.e., the individual contributing the most DNA to the sample), contributing at least 50%–60% of the DNA in the mixture.

Note. This table is not exhaustive and does not represent all submission criteria for every FGG vendor laboratory, but rather provides a general overview of criteria and successes within the field. The numeric values are based on reported successes and will vary across vendor laboratories. Law enforcement investigators are encouraged to contact vendor laboratory representatives to discuss specific cases and associated evidence to determine eligibility for submission.

Considerations When Choosing an FGG Vendor Laboratory

Deciding which DNA vendor laboratory to use for FGG analysis can be a daunting task, because there are many options to choose from. In collaboration with local crime laboratory representatives, law enforcement investigators should consider the vendor's offered services, its processes and procedures, and its ability to provide examples of successful cases resulting from its FGG analysis. The following questions are offered as suggestions to guide conversations between prospective clients (law enforcement investigators and local crime laboratory representatives) and FGG vendor laboratories.

³ Ibid.

- ◆ **What services are offered by the vendor laboratory?** FGG-related services include SNP testing, WGS, DNA extractions, genealogy (i.e., family tree building), and target testing (also known as reference testing). Not every FGG vendor laboratory offers the same types of services. Law enforcement investigators can help streamline the analysis process and help ensure that the optimal service is available to meet the needs of each case by identifying a laboratory that offers multiple services.
- ◆ **Does the vendor laboratory outsource any services to another laboratory?** It is not uncommon for a vendor laboratory to advertise a particular service (e.g., WGS) that is not completed in-house but is outsourced to another laboratory. Law enforcement investigators should be aware of outsourced services and ensure that the receiving laboratory is able to comply with the submitting agency's chain-of-custody requirements.
- ◆ **Is a quality control (QC) step included in the vendor laboratory's workflow?** Many private vendor laboratories have incorporated a QC step within their processes to determine whether the quantity and quality of the extracted DNA is sufficient to continue with FGG. If the DNA passes this QC step, the vendor laboratory will continue with the analysis. If the laboratory determines that the DNA is insufficient, the process should be halted, potentially preserving the sample and saving the submitting agency resources (e.g., time, money). If a sample does not pass the QC stage, law enforcement investigators and crime laboratory representatives should be guaranteed notification by the vendor laboratory so all parties can collaborate on a strategy for how to proceed.
- ◆ **What types of samples are accepted for FGG analysis by the vendor laboratory?** FGG analysis is possible for many different sample types, including DNA extracted from prior analyses, biological samples (e.g., blood, saliva, semen), and skeletal remains, as well as other evidentiary items (i.e., items collected from the crime scene, such as clothing or cigarette butts). However, not all vendor laboratories have the capability to process every type of sample with their current in-house procedures and techniques.
- ◆ **How many nanograms of DNA does the vendor laboratory require?** The amount of DNA required within a sample varies across FGG vendor laboratories because of variances between laboratories' FGG techniques.
- ◆ **How many similar cases has the vendor laboratory helped law enforcement resolve through FGG analysis?** It is best practice to determine whether the vendor has been able to successfully resolve cases similar to those pending submission. For example, if seeking to submit a cold case with highly degraded DNA evidence, law enforcement investigators should ask the vendor laboratory staff how many other cold cases with highly degraded DNA have been resolved as a result of their analysis.
- ◆ **Does the laboratory vendor have references from other law enforcement agencies?** Other law enforcement agencies can describe firsthand experiences of working with the vendor laboratory. When contacting references, investigators should consider discussing not only cases that the vendor laboratory helped to resolve, but also communication styles, responsiveness, and overall willingness to include law enforcement throughout the process.

For a list of FGG vendor laboratories, see **Table 2**.

Table 2. FGG Vendor Laboratories

FGG Vendor Laboratory	Website
Astrea Forensics	https://www.astreaforensics.com/
Bode Technology	https://www.bodetech.com/
DNA Labs International (DLI)	https://dnalabsinternational.com/
DNA Solutions	https://www.dnasolutionsusa.com/
Gene by Gene	https://genebygene.com/
Othram	https://othram.com/
Parabon Nanolabs	https://parabon-nanolabs.com/

Note. This list is not exhaustive and does not represent all vendors; inclusion does not represent BJA's or SAKI's recommendation or endorsement.

Conclusion

The ability to conduct genealogy research (i.e., to build family trees) that lends to the generation of investigative leads for criminal investigations largely depends on the ability to develop quality DNA data. Although the DNA technologies associated with FGG continue to evolve, there are still limitations to the technique that inhibit this tool from resolving every case with DNA evidence. Law enforcement investigators and local crime laboratory representatives should exercise due diligence to (1) identify cases that meet submission guidelines as set forth by the [U.S. Department of Justice Interim Policy on FGG](#), (2) identify DNA evidence of sufficient quantity and quality, and (3) select an FGG vendor laboratory capable of analyzing such evidence. It is the responsibility of all parties involved to ensure that evidence being submitted is believed to be of sufficient quantity and quality to produce informative and useful results. To minimize the unnecessary consumption of evidence, cases deemed to have insufficient DNA by local crime laboratory representatives and vendor laboratory representatives should not be submitted, but rather retained for future consideration as technology and science in the forensics field advance.

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