SWGDAM Resource Document: Forensic DNA Analysis – Team Approach

Purpose

Explain the use of the team approach[1] in the forensic DNA analysis process, the highly standardized and monitored nature of its usage, and based on survey results, its prevalence in forensic DNA laboratories in the United States.

Statement of Interest

SWGDAM is a forensic DNA working group, established over 25 years ago, to "serve as a forum to discuss, share and evaluate forensic biology methods, protocols, training, and research to enhance forensic biology services…" SWGDAM is comprised of dedicated forensic scientists, from international, Federal, State and Local forensic DNA laboratories as well as guests representing academia and other Federal agencies. These forensic scientists serve as the DNA technical leaders or Combined DNA Index System (CODIS) Administrators for their laboratories and offer the perspectives of practitioners in the areas of STR, Y STR, mitochondrial DNA and next generation sequencing (NGS) technologies. SWGDAM also benefits from Subject Matter Experts (SMEs) and invited guests that participate in SWGDAM and Committee meetings to provide their specific expertise in areas such as population genetics, Rapid DNA, probabilistic genotyping, next generation sequencing, statistics, etc.

Forensic DNA Analysis Process

The forensic DNA analysis process can be separated into defined steps or stages, such as extraction, quantification, amplification, capillary electrophoresis and interpretation.[2] A brief description of each follows:

- **Extraction/Purification** is the isolation of the DNA from a biological sample by breaking down the cells and removing proteins and other cellular material.
    - The biological sample is placed in a small tube where chemicals are added to dissolve the cellular membranes and proteins and to release the DNA (lysis). The DNA is then isolated and the rest of the cellular material and chemicals are

[1] For purposes of this Resource Document and the survey of forensic DNA laboratories, a team approach is defined as "involving more than one laboratory staff person".

[2] See also Organization of Scientific Area Committees for Forensic Science (2022) *Human Forensic DNA Analysis Process Map.* Available at https://www.nist.gov/system/files/documents/2022/05/05/OSAC%20Forensic%20Biology%20Process%20Map_5.5.22.pdf.

washed off. The washing step effectively flushes out substances that can hamper DNA typing (purification).

- **Quantification** is the determination of the quantity of DNA in an extracted sample.
    - A common method of measuring the amount of DNA in a sample is quantitative real-time Polymerase Chain Reaction (also known as qPCR). With qPCR, amplification of DNA is monitored in real-time as copies of DNA are generated and the florescent signal produced during this process is associated to a quantity of DNA within the extracted sample.
- **Amplification** is the repeated copying of the DNA extract through Polymerase Chain Reaction (PCR).
    - This PCR technique is similar to that from the quantification step, however, at this point in the analysis, specific markers within the genome are copied to develop a DNA profile for the sample.
- **Capillary electrophoresis** is the separation of the amplified DNA fragments by an electric current (whereby DNA fragments travel through a gel at different speeds depending on their size) to generate the visual representation of the DNA profile, visualized as peaks on a graph.
    - The capillary electrophoresis software allows for identification of the specific DNA types detected in each sample.
- **Interpretation** is the verification of the DNA results, the assessment and subsequent comparison, statistical analysis and reporting.
    - "The verification of the DNA typing results involves a review of peak designations and other software-generated information, as well as an evaluation of quality controls. Based on this data assessment, the DNA analyst performs interpretation, makes comparisons among samples (where appropriate) and draws conclusions. The conclusions reached as part of the interpretation process are compiled into a written report by the DNA analyst. These data and conclusions are then subjected to technical and administrative review prior to issuing a final laboratory case report."[3]

These analytical steps are easily distinguished by task and their stage in the forensic DNA analysis process and are therefore amenable to separation and assignment to multiple DNA personnel (i.e., screeners, technicians, DNA analysts, technical reviewers). Laboratories performing forensic DNA analysis and generating a DNA profile for inclusion in the Combined DNA Index System (CODIS) and the National DNA Index System (NDIS) follow standards

[3] Scientific Working Group on DNA Analysis Methods (2021) *SWGDAM Interpretation Guidelines for Autosomal STR Typing by Forensic DNA Testing* Laboratories; available at https://www.swgdam.org/publications.

designed to produce accurate and quality DNA results; these quality measures and additional checks and balances are discussed further in the Quality Assurance Standards section.

With the growing demand for forensic DNA analysis, studies have examined the forensic DNA analysis process to recommend best practices for the generation of consistent, efficient and quality DNA results. One such study in which SWGDAM participated culminated in the U.S. Department of Justice's National Institute of Justice publication of *Best Practices for Improving DNA Laboratory Process Efficiency.* Among the report's over sixty recommendations was an express endorsement of the team approach in forensic DNA casework laboratories –

> "To maximize workflow and reduce redundancies, the laboratory should adopt a team approach to casework whenever possible."[4]

Many forensic DNA laboratories have chosen to employ a team approach whereby the various steps/stages of the forensic DNA analysis process are conducted by separate laboratory personnel.[5] For example, one or more analysts or technicians may perform the extractions, quantifications, amplifications and capillary electrophoresis steps while a different scientist interprets the DNA results, makes comparisons, applies statistical calculations, and prepares the report of the analyses. The *Best Practices for Improving DNA Laboratory Process Efficiency* recommendations describes another example of the team approach that employs specific days of the week for each stage of the process, as follows[6]:

> An example of a two- to three-person team's schedule for completing a batch of 6-8 cases is as follows:

Day 1	Day 2	Day 3	Day 4
Extraction, Quantification, Amplification	Capillary Electrophoresis, Interpretation	Interpretation, Report Writing	Review

Examples of other team approaches were reported in response to a SWGDAM survey (described in detail below) and describe their specific duties for the various positions. For example, DNA

[4] National Institute of Justice, *National Best Practices for Improving DNA Laboratory Process Efficiency.* Available at https://www.ojp.gov/pdffiles1/nij/304051.pdf. This recommendation also cautions that this approach may not actually achieve efficiencies if implemented in a jurisdiction requiring "all scientists who process a sample to testify".

[5] The team approach has been used in the DNA analysis of database samples and recognized in the first revision of the Quality Assurance Standards in 2009 with respect to proficiency testing requirements; see *Quality Assurance Standards for DNA Databasing Laboratories*, Standard 13.1.4.1, Effective July 1 2009; available at Forensic Science Communications, October 2008: Vol. 10, No. 4; https://ucr.fbi.gov/lab/forensic-science-communications/fsc/oct2008/standards/standards01a.pdf.

[6] *National Best Practices for Improving DNA Laboratory Process Efficiency.* At Page 15.

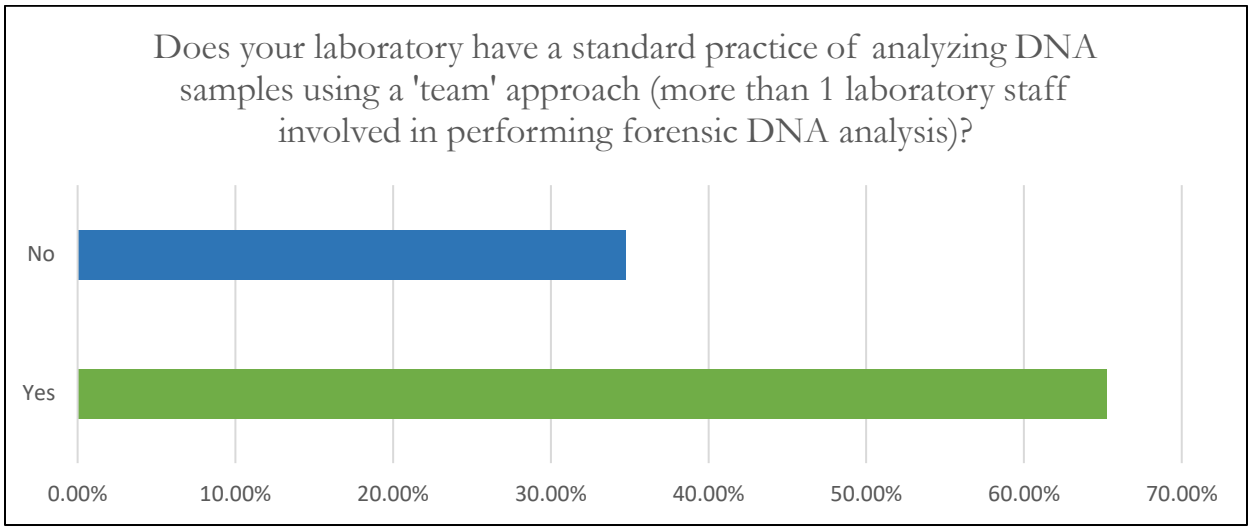
technicians perform DNA extraction and quantification while the DNA analysts conduct DNA amplification and typing, interpret the data and author reports as well as perform the technical review of batch paperwork at each analytical step before samples are moved to the next step of analysis. Another laboratory reported a team approach using a six-stage process as follows:

> Step 1 - Case Assessment = DNA Analyst or Biological Screener
> Step 2 - Biological Screening = DNA Analyst or Biological Screener
> Step 3 - Reference Standard DNA Lab Work = DNA Analysts or Technicians
> Step 4 - Reference Standard DNA Interpretation = DNA Analyst
> Step 5 - Unknowns DNA Lab Work = DNA Analysts or Technicians
> Step 6 - Unknowns DNA Interpretation = DNA Analyst
>
> Each step may have a different person involved.[7]

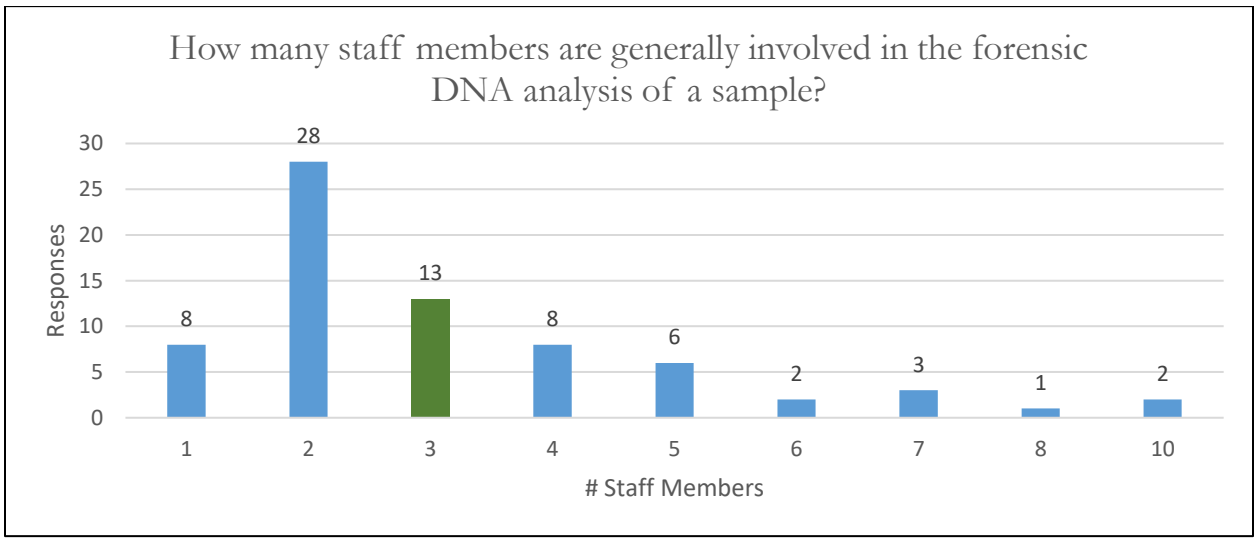
SWGDAM's Survey of Forensic DNA Laboratories indicates that a Majority of Laboratories Employ a Team Approach

To assess how prevalent the current use of the team approach is in forensic DNA laboratories in the United States, SWGDAM designed a survey that was distributed to the forensic DNA laboratories that participate in the National DNA Index System. The survey consisted of 6 questions.[8] Of the 94 laboratories that responded, approximately 65% indicated that they employ a team approach (see below).

[7] The laboratory differentiated the various positions as follows: "Biological Screener" is competent in biological screening, but not DNA lab work or analysis. "DNA Technician" is competent in DNA lab work but not biological screening or DNA analysis. "DNA Analyst" may be an entry level analyst, a senior analyst, a DNA Technical Leader, or a DNA Supervisor and is competent in biological screening, DNA lab work, and DNA analysis.
[8] This 6-question survey was e-mailed to approximately 200 forensic DNA laboratories during December 2023. The responses were tabulated and shared with the SWGDAM body at their January 2024 meeting.



Those laboratories responding to the survey reported, on average, a range of two to ten personnel involved in the team approach at their laboratories with the average being three personnel.

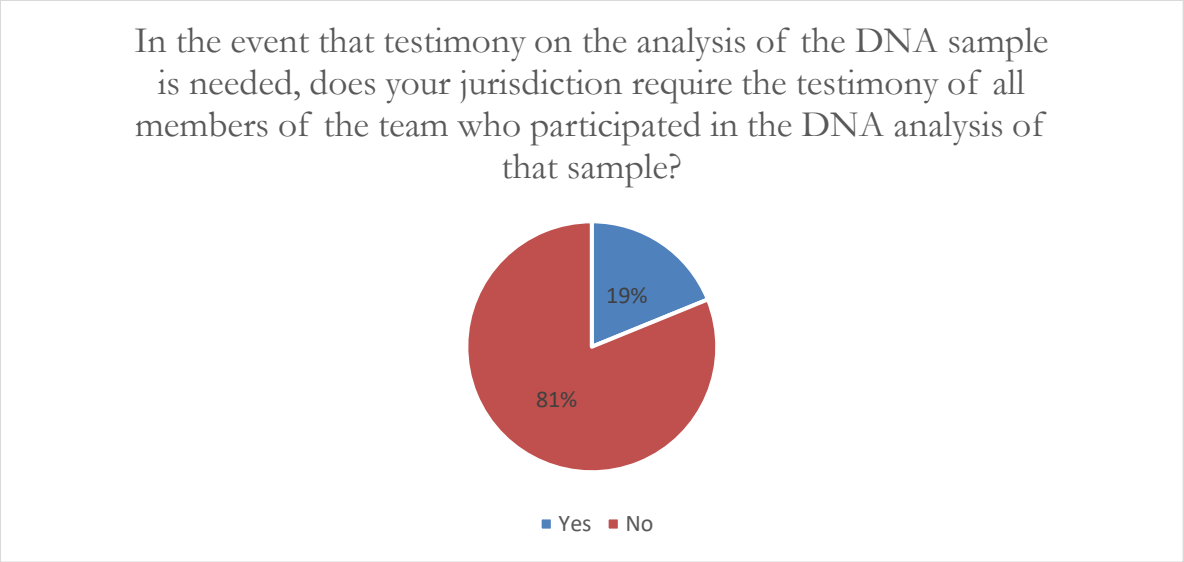


The laboratories reported the following positions involved in the team approach for forensic DNA analysis:

- Forensic Technicians
- Forensic Scientists
- Criminalists
- Examiners/Analysts
- Submitting and Batching Analysts
- Technical Leader, Training Coordinator
- Technologist/Senior Technologist
- Forensic Molecular Biologist
- Director of Laboratory Operations

- Technical Reviewers and Administrative Reviewers
- Serologists

Of the 69 laboratories responding that they employ a team approach, 13 laboratories or almost 19% of the respondents indicated that they require the testimony of all members of the team who participated in the DNA analysis.



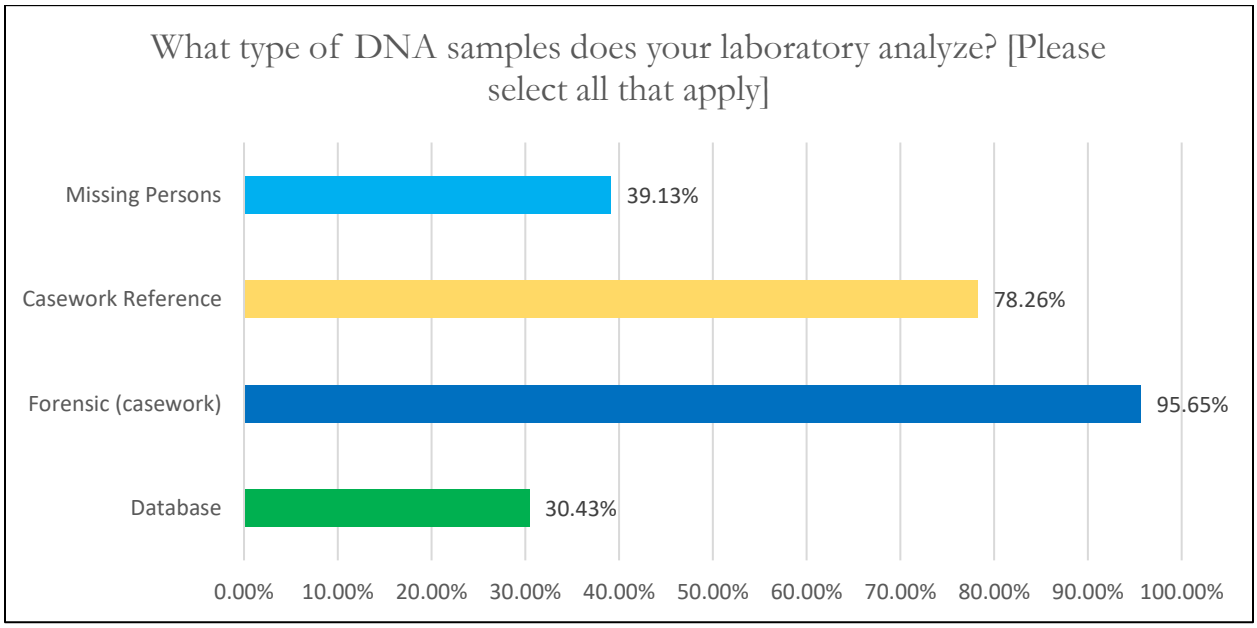
Those laboratories whose jurisdictions do not require the testimony of all members of the team report that the following personnel testify about the DNA analysis performed by the team:

- Forensic Scientist
- Reporting Analyst (29)[9]
- Examiner/Analyst and sometime Technician
- Screening Analyst and Reporting Analyst (9)
- May call all who participated in the analysis
- Submitting and Batching Analysts
- Technical Leader, Training Coordinator
- Technologist/Senior Technologist
- Forensic Molecular Biologist
- Director of Laboratory Operations
- Technical Reviewers and Administrative Reviewers
- Serologists

[9] Numbers following the position represent the number of laboratories reporting that position or combination of positions.

Anecdotally, laboratories report a variety of scenarios for court testimony. For example, one respondent notes that routinely two personnel provide court testimony - the DNA analyst who authored the report and the DNA technician or screener who first opened the evidence, inventoried the contents, and selected samples for analysis. In this way, the chain of custody is established through the personnel (DNA technician or screener) who opened the evidence and the DNA analyst testifies specifically to the analysis, interpretation and conclusions. Another example reported by a laboratory has the reporting analyst or technical reviewer testify in the cases in their jurisdiction. One laboratory reported that in their jurisdiction, the personnel who conduct the screening, testing and sample the item and the personnel who interpreted the DNA results will routinely be called to testify.

Almost all of the laboratories responding that they employ the team approach reported that they analyze forensic (casework) samples; however, laboratories may also analyze database, casework reference and missing person samples.



Quality Assurance Standards, Accreditation and Audits Are Required for Forensic DNA Laboratories Contributing DNA Records to the National DNA Index System

Laboratories performing forensic DNA analysis and participating in the FBI's National DNA Index are subject to Federal statutory requirements relating to quality assurance and privacy. Since 1998, laboratories seeking to participate or participating in the National DNA Index System or NDIS are required to comply with standards for a quality assurance program relating to the following subject areas:

- Personnel qualifications (education, experience, training and professional development)
- Facilities and sample control
- Validation
- Analytical procedures (including reagents, analytical controls, thresholds and statistical calculations)
- Equipment (including performance checks)
- Reports (documentation and confidentiality)
- Review (administrative and technical – controls, internal size standards, allelic ladders and raw/analyzed data, and statistical analysis)
- Proficiency testing (semi-annual accredited external testing)
- Corrective action
- Audits (annual audits and external audits every two years)
- Outsourcing (accredited vendor laboratories, approval of technical specifications, verification of integrity of DNA data and on-site visits)[10]

Following implementation of the National DNA Index System, accreditation was encouraged for participating laboratories and by 2006 federal law required accreditation by forensic DNA laboratories contributing DNA records to the National Index. All forensic DNA laboratories participating in, and generating DNA records for upload to, NDIS are accredited by a nonprofit professional association of practitioners actively involved in forensic science that is nationally recognized within the forensic science community.[11] In addition to generating these DNA records in accord with specific standards for a quality assurance program, these laboratories also abide by defined access and disclosure rules for their DNA records. Federal law also requires that these laboratories undergo an external audit every two years to document their compliance with the federally mandated standards. These external audits are also independently reviewed by a panel of Federal, state and local forensic scientists to ensure compliance with the *FBI Director's Quality Assurance Standards for DNA Databasing and Forensic DNA Testing Laboratories*.[12] The U.S. Department of Justice's Office of the Inspector General also conducts audits of CODIS laboratories for compliance with the Federal DNA Act requirements as well as the NDIS Operational Procedures Manual.[13] In addition to this rigorous program of audits and accreditation, the FBI's CODIS Unit conducts assessments of the NDIS participating laboratories as part of their administration of the National DNA Index System.[14]

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[10] See Federal Bureau of Investigation, *Quality Assurance Standards for DNA Databasing Laboratories* and *Quality Assurance Standards for Forensic DNA Testing Laboratories*, Effective July 1, 2020; available at https://le.fbi.gov/science-and-lab/biometrics-and-fingerprints/codis

[11] See 34 U.S.C. § 12592 (b)(2)(A)(i).

[12] This external audit review process is described in greater detail in the NDIS Operational Procedures Manual, Section 1.3 entitled "Quality Assurance Standards External Audit Review Process" available at https://le.fbi.gov/science-and-lab/biometrics-and-fingerprints/codis.

[13] *See Combined DNA Index System Audits*, available at https://oig.justice.gov/reports/codis-ext.htm.

[14] Beyond this federal regulation of forensic DNA laboratories, several states also have established supplementary levels of oversight provided by State forensic oversight boards that review, evaluate and approve new technologies

Conclusion

The SWGDAM survey confirmed that the team approach has been implemented in a majority of the forensic DNA laboratories in the United States. The SWGDAM survey also revealed variation among laboratories in how the team approach is implemented as well as the number of personnel comprising the team. Moreover, this survey also highlighted that laboratories consider jurisdictional rules in determining the personnel needed to testify in court. While forensic DNA processes and protocols continue to be subject to oversight through a system of annual audits, external audits, assessments and accreditation, the team approach is currently being employed across laboratories to foster consistency, achieve efficiencies and to ensure quality work.

or methods prior to their use by forensic DNA laboratories, such as, the Connecticut DNA Data Bank Oversight Panel, the District of Columbia's Scientific Advisory Board, the Massachusetts Forensic Science Oversight Board, the New Mexico's DNA Oversight Committee, the New York State Commission on Forensic Science and DNA Subcommittee, the Texas Forensic Science Commission, and the Virginia Forensic Science Board and Scientific Advisory Committee. For a more complete listing of State Forensic Oversight entities and Forensic Commissions, see Ropero-Miller, J.D., and N. Jones. (2022) *Forensic Science State Commissions and Oversight Bodies—A 2022 Update*. Research Triangle Park, NC: RTI International.