



National Best Practices for Improving DNA Laboratory Process Efficiency



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Executive Summary



DNA forensic laboratories are at a crossroads. Faced with a rising demand for analysis and constrained by limited financial resources, laboratories must find new and innovative ways to reduce backlogs and increase productivity.

The recommendations in this guide, authored by experts in forensic science and laboratory management, are aimed at improving efficiency in a multitude of essential tasks that DNA forensic laboratories routinely perform. These tasks range from hiring and training personnel to formulating and enforcing case acceptance policies, implementing existing and new technologies and methodologies, managing casework and tracking laboratory workflows, analyzing data, and compiling final reports that nonscientists can comprehend. This guide's recommendations are also designed to help laboratories anticipate changes — including technological advances and new legislation — that may affect their caseloads.

Chapter 1 recommends several ways to improve efficiency in laboratory management and operations. Casework staff should dedicate their time to casework, adopt a team approach to analyzing data whenever possible, and minimize time spent on ancillary tasks. Designated leaders in the laboratory should conduct independent evaluations to identify inefficient processes and to define and quantify backlogs. Leaders should also use metrics to monitor demand, laboratory analysis, turnaround times, and analyst performance. Evidence screening and DNA analysis should be separate, and screening should be conducted using a Y-screening or direct to DNA approach.

Chapter 2 discusses case acceptance and emphasizes that every DNA laboratory must have a clear acceptance policy that is accessible and comprehensible to all stakeholders. The laboratory should designate an individual or team to ensure the consistent application of the policy and to periodically assess the policy's effectiveness. Just as important, the laboratory should have a written, clearly defined case prioritization policy that laboratory staff can consistently apply. The laboratory should also designate and train personnel who are responsible for prioritizing cases.

Chapter 3 cites several strategies for finding, training, and retaining a high-caliber quality staff. These strategies include broadening the pool of potential candidates by establishing outreach programs with local

colleges that have forensic science programs and creating student internships. Candidate screening should involve several steps — phone and in-person interviews, reference checking, opportunities to meet co-workers and supervisors, and the chance, if possible, to work in the laboratory for a day. These steps ensure that potential hires have both the scientific and personal qualifications to work efficiently and smoothly as part of the laboratory's team. The laboratory should implement a standardized onboarding program to integrate new employees and also initiate a probationary period to evaluate the employees' capabilities. Training, which should be overseen by a designated coordinator, should be divided into modules and include only job-relevant components. The training program should be time-limited, and employees should receive feedback on their performance during training and throughout their career in the laboratory. To reduce attrition, the laboratory should develop strategies to promote the personal and professional growth of employees.

Chapter 4 reviews information technology and data management. This chapter notes the importance of using software tools to speed the review of allelic ladders, controls, and samples and to determine the number of contributors to a DNA sample. Whenever possible, software output should be customized so that it contains only information relevant for assessment and review of the data. The laboratory should use probabilistic genotyping software based on a continuous model for the interpretation of DNA typing results and statistical analysis. The chapter also emphasizes the central role that a laboratory information management system (LIMS) plays in identifying backlogs; tracking, storing, and retrieving data; monitoring case submission; and increasing efficiency. Every laboratory must have a LIMS, but before purchasing such a system, the laboratory must ensure that the software can be tailored to its needs and that a dedicated information technology staff is in place to oversee LIMS operation.

Chapter 5 discusses new technologies for the DNA laboratory and reviews several criteria for determining the laboratory's technology needs. To choose a new technology wisely and efficiently, the laboratory should evaluate current bottlenecks and short- and long-term plans. It should also anticipate changes in facilities, information technology, safety procedures, and physical and personnel resources that may be needed to accommodate the new technology. To minimize delays in purchasing new technologies and validations, designated laboratory personnel should have a full understanding of their agency's procurement processes, based on training and consultation with financial personnel. To shorten the time from purchase to routine use of the new technology, the laboratory should develop a detailed plan to ensure the successful and timely completion of all testing, protocol development, and summarization of the validation work.

List of Recommendations by Chapter

Chapter 1: Laboratory Management and Operations

Recommendation 1: A DNA laboratory should designate personnel who have leadership roles and defined responsibilities.

Recommendation 2: Casework staff should be fully dedicated to DNA casework activities and minimize involvement in ancillary tasks that can lessen a laboratory's efficiency and productivity.

Recommendation 3: To minimize casework disruption, a DNA laboratory should devise a proficiency testing schedule so that not all individuals are tested at the same time.

Recommendation 4: A DNA laboratory should engage in an independent, external, process improvement exercise to identify areas of inefficiency and maximize case output.

Recommendation 5: To maximize workflow and reduce redundancies, the laboratory should adopt a team approach to casework whenever possible.

Recommendation 6: To effectively monitor casework operations and identify areas for efficiency improvement, DNA laboratories should define their backlog to include both unassigned cases and those that have been assigned but whose results have not yet been reported.

Recommendation 7: Laboratories should have a metrics tracking method to monitor increases or decreases in demand, laboratory analysis, turnaround times (TAT), and analyst performance.

Recommendation 8: A DNA laboratory should separate the processes of evidence screening from DNA analysis in order to standardize workflow and increase the predictability of case output.

Recommendation 9: To decrease sample processing time and maximize laboratory resources, a DNA laboratory should adopt a Y-screening and/or direct to DNA approach for screening evidence samples for DNA.

Recommendation 10: To decrease analysis time and reduce sample consumption, traditional serological testing and sperm searches should be conducted only when necessary.

Recommendation 11: To decrease time spent performing bench work, a DNA laboratory should employ automated techniques in the DNA processing steps whenever possible.

Recommendation 12: To decrease the time spent and number of analysts/individuals performing bench work, the laboratory should employ batching at each step of the DNA process.

Recommendation 13: A DNA laboratory should implement a method for regularly evaluating the functional elements of the laboratory in order to ensure quality, monitor growth, and avoid process decline.

Chapter 2: Accepting the Case: Evidence Submission, Request Prioritization, and Stakeholder Training

Recommendation 14: Every forensic DNA laboratory should have documented evidence submission guidelines, including a detailed list of submission requirements (e.g., limitations on the number of items, in accordance with offense type) that is clearly communicated to submitting agencies. (See appendix A for an example policy.)

Recommendation 15: Laboratories should consider a tiered approach to evidence submission both as a means to control the amount of evidence coming into the laboratory and the amount of testing conducted within a case. This approach will shorten the turnaround time between submission and the final report.

Recommendation 16: To collect pertinent case information and reinforce the laboratory's policy, the evidence submission process should include a standardized, web-based form for initiating a submission request.

Recommendation 17: The laboratory should have a method for reviewing submission requests and providing consultation, when necessary, prior to acceptance to assist submitters' selection and prioritization of items.

Recommendation 18: A laboratory should designate an individual or team to ensure the consistent application, enforcement, and accountability of the evidence submission guidelines to prevent acceptance of noncompliant submissions and unnecessary disruption to analysts.

Recommendation 19: Laboratories should have written, clearly defined case prioritization guidelines that laboratory staff can consistently apply. This will eliminate unnecessary interruptions that delay testing.

Recommendation 20: Laboratories should designate and train personnel who are responsible for prioritizing cases. This ensures compliance with the policy, preventing unnecessary disruption to analysts, and shortening overall laboratory turnaround time.

Recommendation 21: Requests for expedited analysis should be reviewed and approved by a limited number of laboratory management personnel to ensure consistent application of policies.

Recommendation 22: The laboratory should conduct a periodic review of the policy to evaluate its effectiveness, whether stakeholder needs are being met, and whether modifications are warranted.

Recommendation 23: The laboratory should train stakeholders about its scientific capabilities, policies, and procedures, and provide periodic updates as necessary. Ensuring that stakeholders have an up-to-date and clear understanding of laboratory operations minimizes unnecessary questions that distract the analyst and disrupt laboratory workflow.

Recommendation 24: Laboratories should develop innovative and effective means for training and educating stakeholders.

Recommendation 25: Laboratories should develop effective communication with all appropriate stakeholders to ensure timely discussions and decisions regarding case analysis. Implementation of effective communication mechanisms throughout the process can eliminate unnecessary interruptions that can strain a laboratory's resources and delay testing.

Chapter 3: Staffing: Hiring, Training, and Retention

Recommendation 26: To increase the pool of qualified candidates, laboratories should establish outreach programs that market careers in forensic DNA testing to students.

Recommendation 27: To increase efficiency through staffing, laboratories should consider using non-agency funding as a stop-gap measure until permanent agency funding is available.

Recommendation 28: To increase the pool of potential employees, laboratories should offer volunteer opportunities and internships in partnership with forensic science academic programs.

Recommendation 29: Laboratories should have a full understanding of their current hiring practices and adopt a multistep approach to more efficiently screen candidates.

Recommendation 30: The laboratory should implement a standardized onboarding program to integrate new employees into the laboratory.

Recommendation 31: Upon hiring, laboratories should initiate a probationary period in order to evaluate the employee's ability to perform the job successfully.

Recommendation 32: To allow maximum flexibility in the allocation of resources, the laboratory should implement a standardized modular training program consisting of only job-relevant components.

Recommendation 33: Every laboratory should have a designated training coordinator to help prioritize and oversee all training activities.

Recommendation 34: The laboratory should establish a timeline for the training program in which the training coordinator monitors progress to ensure training remains a priority.

Recommendation 35: The laboratory should incorporate feedback from trainees into training programs.

Recommendation 36: The laboratory should provide feedback to employees on their performance during training, after training, and throughout their careers.

Recommendation 37: To reduce attrition and maintain lab efficiencies, the laboratory should develop strategies to promote employee professional and personal growth.

Chapter 4: Data Analysis, Data Management, and Information Technology

Recommendation 38: Laboratories should batch the review of data and controls to reduce redundancy in the technical review process.

Recommendation 39: Laboratories should explore and validate software tools to facilitate the review of allelic ladders, controls, and samples.

Recommendation 40: Laboratories should implement software tools or an interpretation strategy to determine the number of contributors in a DNA sample.

Recommendation 41: Laboratories should use probabilistic genotyping software based on a continuous model for the interpretation of DNA typing results and statistical analysis.

Recommendation 42: Laboratories should invest in strategies and developments that have the potential to improve efficiency in data analysis and probabilistic genotyping workflows.

Recommendation 43: Laboratories should customize software output, where possible, to include only relevant information for assessment of the data and review.

Recommendation 44: Laboratories should continually explore ways to improve the efficiency and accuracy of technical and administrative reviews to aid in timelier issuance of reports.

Recommendation 45: Communication of preliminary results should be limited to exigent situations to preserve resources and maintain efficiency in normal casework analysis.

Recommendation 46: Laboratories should identify and clearly define conditions under which statistical analysis is not required and reporting can be abbreviated.

Recommendation 47: Laboratories should streamline communication of results through the laboratory report by using standardized statements and formatting, facilitated by software tools.

Recommendation 48: Laboratory reports should include supplementary information to aid laypersons in understanding the meaning and context of the information and to document any relevant limitations.

Recommendation 49: Laboratories should have a documented strategic information technology (IT) plan to support current operations as well as future needs and developments.

Recommendation 50: Laboratories should staff dedicated in-house IT professionals to decrease the time the DNA analysts spend on troubleshooting connectivity and other IT issues.

Recommendation 51: Laboratories should have an IT system that provides secure, real-time access to information to facilitate efficiency in case processing.

Recommendation 52: Laboratories should have ample computing capacity to efficiently analyze and store complex and large data files.

Recommendation 53: Laboratories should use a LIMS to track and manage casework activities and store and retrieve case-related information.

Recommendation 54: Laboratories should use a LIMS to identify trends and bottlenecks to manage resources, maintain efficiency in sample processing and case administration, and meet performance goals.

Recommendation 55: Laboratories should use a LIMS to identify and evaluate case acceptance trends relative to laboratory capacity.

Recommendation 56: Before selecting a LIMS, a laboratory should consider system requirements; projected needs and costs of customization; and user-acceptance testing, training, and implementation; and then prepare a purchase strategy that includes a budget for future growth, maintenance, and IT support.

Chapter 5: Best Practices for New Technologies

Recommendation 57: To choose new technologies wisely and efficiently, laboratories should consider bottlenecks as well as short- and long-term plans.

Recommendation 58: A laboratory should anticipate potential changes in facilities, IT, safety, and physical and personnel resources to accommodate the new technology.

Recommendation 59: To minimize delays in purchasing new technologies and validations, designated laboratory personnel should have a full understanding of their agency's procurement processes, based on training and consultation with financial personnel.

Recommendation 60: Laboratories are encouraged to publish validation studies to aid other forensic DNA laboratories in efficiently designing their own validation studies.

Recommendation 61: The laboratory should develop a detailed plan to ensure the successful and timely completion of all testing, protocol development, and summarization of the validation work.

Recommendation 62: Throughout the course of validation testing, the laboratory should document key decision points and critical elements to efficiently develop training, operational and technical protocols, and summarization documents.

Recommendation 63: The laboratory should appoint a team to develop a documented implementation plan to ensure seamless, timely, and efficient training and technology implementation.

Recommendation 64: The implementation coordinator should guide the development and consistent delivery of a training plan for end users of the newly validated method to ensure both adequate training and timely completion.

Recommendation 65: After implementing a new technology, the laboratory should evaluate protocols to identify new efficiencies within the workflow.

Recommendation 66: The laboratory should implement a plan for DNA analysts to refresh and reinforce theoretical concepts, maintain competence, and minimize nonconforming work.

Recommendation 67: When new and unexpected complications arise post-implementation, the laboratory should be prepared to investigate and resolve them.

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Foreword



During the 1990s, it was not uncommon to enter a forensic DNA laboratory recently retrofitted from a detective bureau or storage area, or added on to a local law enforcement crime laboratory.

Today, laboratories conducting DNA analysis on casework evidence are operated by specialized personnel within dedicated, accredited facilities and have universal oversight and sustained budgetary support from local, state, and federal agencies. The 30-year evolution of forensic DNA practices is attributable to visionaries within academic, forensic, judicial, manufacturing, and governmental fields. During these years, DNA analysis steadily transformed from a topic of research primarily outside the forensic sciences to a powerful instrument in the pursuit of justice. Indeed, this power is most evident when a forensic DNA test is used to differentiate one human being from another, demonstrate links between different crime scenes, return previously unidentified human remains to a family, or populate the ever-expanding DNA databases that help law enforcement protect and serve the communities in which we live.

National Best Practices for Improving DNA Laboratory Process Efficiency is a compendium of recommendations designed to guide forensic DNA laboratory stakeholders through critical scientific and policy decisions. It was created by the DNA Laboratory Efficiency Improvement Working Group, formed in late 2018 by the National Institute of Justice (NIJ) to assist in creating a necessary paradigm shift in the operations and management of DNA laboratories in order to support and maintain their ongoing increase in workload and needed capacity. The group, which met four times from 2019 to 2020, consisted of 38 federal, state, and local DNA analysts, technical leaders, section supervisors, and laboratory directors. All of these individuals are considered experts in the field of forensic DNA analysis, and their agencies were all recipients of funding from NIJ's Office of Investigative and Forensic Sciences, most under the DNA Capacity Enhancement and Backlog Reduction Program.¹ NIJ supplied three physical scientists and four contract staff to the project.

¹ The DNA Capacity Enhancement and Backlog Reduction (CEBR) Program was transferred from NIJ to the Bureau of Justice Assistance in 2020.

The guide is based on processes refined over decades of forensic DNA practice. Consider the myriad committee reports, thousands of publications, countless national and international meetings, and many specialized journals that have been generated from the world of DNA forensic science. Molding the lessons learned from these sources into a comprehensive instruction manual is an impressive achievement by the DNA Laboratory Efficiency Improvement Working Group.

Quality-based processes that have emerged over the decades have provided foundational roadmaps for traversing the forensic DNA landscape. The DNA practices cover an immense terrain marked by laboratory operations, hiring and training, educational requirements, managing data, testifying in court, validating new methodologies, certification, researching innovative technologies, and understanding the impact of human factors.

The working group conducted considerable research to produce this document. Its authors identified empirical support for each topic and recommendation through work products previously reported by local, state, academic, and federal programs and committees. Many of the forensic DNA committees cited here remain important beacons for maintaining quality assurance and quality control within the discipline. The archetype of such a beacon is the Scientific Working Group on DNA Analysis Methods (SWGAM). An independent body of forensic scientists from international, federal, state, and local forensic DNA laboratories, SWGAM serves as a forum to discuss, share, and evaluate forensic biology methods, protocols, training, and research. Its mission is to enhance forensic biology services as well as provide recommendations to the FBI director on quality assurance standards for forensic DNA analysis. SWGAM also recommends and conducts research to develop and validate forensic biology methods, helping to guide and inform forensic DNA laboratories around the world. Attending meetings of this group is like entering a five-day think-tank factory where a diverse group of experienced, qualified scientists share opinions and proffer suggestions on a vast array of forensic DNA practices. A number of the members of the working group that created this guide have either served or currently serve as members of SWGAM. Ultimately, the goal of all groups focused on forensic DNA is to direct the discipline into the future by providing guidelines and universal standards. This can be accomplished only by remembering where the science has been and how far the science has come.

The working group behind this guide took a careful, deliberative, scientific, and community-based approach to providing a holistic path forward for forensic DNA practices. Importantly, this guide supports and

affirms the ultimate intent of conducting DNA testing in criminal cases: to provide investigative leads, exonerate the innocent, bring closure to victims, and identify true perpetrators.

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Introduction



In the mid-1980s, scientists unveiled a powerful new forensic tool that revolutionized the criminal justice system: DNA analysis. Over the past three decades, analyses performed by forensic DNA laboratories have identified countless suspects and exonerated the innocent. Today, with advances in technology making DNA analysis more accurate and more sensitive, DNA testing is used in criminal cases ranging from burglary to sexual assault and homicide. At the same time, forensic DNA laboratories have gained the capability to extract valuable information from even trace amounts of DNA and challenging biological samples.

As a result of their success, forensic laboratories are now inundated with a greater number of cases than ever before — along with a greater number of samples per case. Even as new techniques have shortened the processing time for DNA samples from months to days, laboratories often cannot keep pace with the vastly increased demand. Delays in analyzing samples due to the overwhelming workload may allow unidentified criminals to commit further crimes.

Although grants awarded by the National Institute of Justice (NIJ) through the DNA Capacity Enhancement and Backlog Reduction Program have increased funding to DNA forensic laboratories, financial support is not enough to solve the problem. Laboratories overwhelmed by the demand for DNA testing must explore processes that will allow them to become more efficient. Even within the constraints of current budgets, laboratories can modify existing practices to operate more efficiently.

To that end, in 2018, NIJ commissioned a group of experts in forensic DNA analysis to research and write *National Best Practices for Improving DNA Laboratory Process Efficiency*. This guide brings together a combination of innovative and practical concepts, recommendations, and promising practices to assist DNA laboratories in increasing their productivity and capacity in a multitude of areas. These include onboarding and effective methodologies for staff training, efficient use and implementation of existing and advanced technologies and methodologies, the creation of strategies to improve process efficiency for casework, and the development of more efficient laboratory workflows. The guide provides forensic DNA laboratories with a roadmap for managing expected increases in case submissions due to stakeholder demand as well as less predictable impacts on caseload due to technological advances and legislative changes.

The recommendations in this guide are intended as best practices applicable to all laboratories with the understanding that the guidelines are not one-size-fits-all. Individual laboratories may have to adapt these recommendations based on funding, staffing, available technology, legislative requirements, local legal ramifications, and laboratory size.

Timeline: A History of Forensic DNA Evidence

Scientists first applied DNA technology to a criminal case in 1986, when police asked geneticist Alec J. Jeffreys of Leicester University in the United Kingdom to confirm the confession of a suspect who claimed to have committed one of two rape-murders in the English Midlands believed to have been committed by the same person. Forensic DNA testing revealed that the suspect had not committed either crime. The police then voluntarily obtained blood and saliva samples from nearly 5,000 men between the ages of 17 and 34 who lived in the region. Soon after the police learned that someone else had provided DNA samples for a man named Colin Pitchfork, he pleaded guilty to both crimes. “If it wasn’t for DNA, you might still be at large today, and other women would be in danger,” the presiding judge told Pitchfork.

Also, in 1986, U.S. prosecutors brought DNA evidence into the courtroom for the first time, using it to help convict a couple accused of murdering an elderly man in their care.²

DNA databases, which law enforcement authorities began building in the early 1990s, have expanded significantly over the years as it became clear that DNA was commonly left at crime scenes and that many suspects were repeat offenders. U.S. investigators and analysts have come to rely on the Combined DNA Index System (CODIS), the national DNA profile repository maintained by the Federal Bureau of Investigation. All 50 states and the federal government have laws that require collecting DNA samples from people who are convicted of certain crimes and uploading the resulting DNA profiles to CODIS. Sex offenders and violent criminals must give DNA samples upon conviction. Most states require collection of DNA samples from anyone who is convicted of a felony. The federal government and some states also require people arrested for certain crimes to provide DNA samples for the database, even if they are not convicted.

A 2008 study in the United States, commissioned by NIJ, found that burglary suspects identified through DNA evidence had at least twice as many felony arrests and convictions as suspects identified through traditional burglary investigations that did not include DNA.³

² Commonwealth v. Pestnikas, 421 Pa. Super. 371, 617 A.2d 1339 (1992).

³ John K. Roman et al., *The DNA Field Experiment: Cost-Effectiveness Analysis of the Use of DNA in the Investigation of High-Volume Crimes*, Washington, DC: Urban Institute, April 2008, <https://www.ojp.gov/pdffiles1/nij/grants/222318.pdf>.

In the decade since that study was published, scientific and technical advances have made DNA analysis even more powerful, accurate, and timely. Training and proficiency testing of laboratory professionals have also improved. Driven by various forces — such as legal challenges to DNA evidence and its interpretation, the growing market for DNA-informed health and family services, and scientific breakthroughs — the level of certainty with which individuals can be identified and characterized using DNA samples of varying amount and quality has increased to a remarkable degree.

It may not be surprising, then, that the demand for DNA forensic testing has outstripped the capacity of many laboratories. According to a U.S. Department of Justice report, the number of forensic biology casework requests received by publicly funded crime laboratories rose 28% from 2009 to 2014.⁴ Data from NIJ show that state and local government laboratories participating in the agency’s DNA Capacity Enhancement and Backlog Reduction program have experienced a similar trend: From 2011 to 2017, the number of DNA submissions that were not processed within 30 days rose by 85% — even as the laboratories consistently processed more requests over time.⁵

⁴ See table 4 in Matthew R. Durose et al., “Publicly Funded Forensic Crime Laboratories: Resources and Services, 2014,” Bulletin, Washington, DC: U.S. Department of Justice, Bureau of Justice Statistics, November 2016, NCJ 250151, <https://bjs.ojp.gov/content/pub/pdf/pffcrls14.pdf>.

⁵ DNA evidence held by a criminal justice agency and not yet submitted to a laboratory is a serious issue, but such evidence is not considered part of the laboratory backlog. Prior to 2011, the definition of a backlog in a DNA laboratory varied from one crime laboratory to the next. One laboratory might consider a backlog as a sample submitted for analysis that had not been completed within 90 days, while another laboratory might allow for a longer processing time. NIJ has created its own definition: A DNA forensic sample is considered part of the backlog if it has not been tested 30 days after the laboratory has received it. That definition is now the standard for crime labs that receive NIJ funding.

Laboratory Management and Operations



The operations and management teams are the lynchpin of any DNA forensics laboratory: They keep the laboratory running smoothly. The vast array of services and processes provided by these teams includes knowledge about instrumentation, implementation of validated methods, process efficiency solutions, analysis and interpretation, personnel matters, and any other processes that affect workflow.

Laboratory Management and Organizational Structure

RECOMMENDATION 1:

A DNA laboratory should designate personnel who have leadership roles and defined responsibilities.

A DNA laboratory's operations depend on several key players whose roles should be clearly defined. These designated personnel should include an administrator (i.e., a manager or supervisor who has oversight over staffing, budget, policies, and strategic planning) and a technical leader (TL) who can make technical decisions in a timely fashion with minimal disruptions to casework.

This oversight ensures that resources are allocated appropriately and in line with the agency's financial plans. The TL maintains technical oversight of all laboratory practices and procedures. Staff who conduct casework, evaluate new methods, perform quality assurance functions, and provide training are also critical to the function of the laboratory.

Administrative Oversight

The laboratory's administrator may be responsible for reviewing performance goals, hiring technical and administrative staff, strategic planning, and establishing budgetary requirements. While it is not required that this individual be an expert in DNA forensics, it is best if the person has a background in and understanding of DNA laboratory processes. The individual with administrative oversight should determine optimal resource levels based on current metrics and projected trends. This individual is accountable for the overall productivity of the laboratory.

“Many laboratory administrative officials are former subject matter experts and have the foundational scientific knowledge and experience to provide insight on technical matters.”

Technical Oversight

Technical oversight of a DNA Laboratory is the role of the TL. According to the FBI's *Quality Assurance Standards for Forensic DNA Testing Laboratories*, the TL "is accountable for the technical operations of the laboratory and ... is authorized to initiate, suspend, and resume laboratory operations."⁶ The TL approves educational requirements for technical staff, approves validation studies and training curricula, and may be included in hiring new staff. Having a single person, rather than a group, responsible for all technical matters improves a laboratory's efficiency, because the trusted individual has wide authority and can make technical decisions quickly, minimizing delays in casework. To have maximum impact, the TL should be dedicated full time to technical oversight. To assist with operations, an experienced scientist should be designated to monitor casework activities and act as a liaison between casework staff and the TL. This will ensure continuity and provide another resource for monitoring and improving efficiency.

RECOMMENDATION 2:

Casework staff should be fully dedicated to DNA casework activities and minimize involvement in ancillary tasks that can lessen a laboratory's efficiency and productivity.

Casework Staff

It is inevitable that casework analysts will at times become involved in training new staff, validations, and other laboratory functions. However, to maximize efficiency of the laboratory, casework staff should remain dedicated to DNA casework the majority of the time. Assigning ancillary forensic functions — such as crime scene response or fingerprint analysis — to DNA casework personnel can significantly lessen a laboratory's efficiency. A laboratory should strive to have individual casework staff work only on a small number of assigned tasks. Laboratories constrained by limited staffing could assign tasks on a rotating basis to benefit the overall operation. For example, specific days of the week could be designated for specific casework support functions: equipment maintenance might occur on Mondays, reagent preparation on Tuesdays. A rotating schedule establishes dedicated time and effort for casework and other laboratory functions.

Whenever possible, a laboratory should consider using contractors for validations and training. This will allow casework staff to focus solely on casework assignments, thus minimizing casework disruptions and

⁶ Federal Bureau of Investigation, "Quality Assurance Standards for Forensic DNA Testing Laboratories," Washington, DC: U.S. Department of Justice, Federal Bureau of Investigation, 2020, 11, <https://www.fbi.gov/file-repository/quality-assurance-standards-for-forensic-dna-testing-laboratories.pdf/view>.

avoiding unnecessary backlogs. Although the TL maintains full oversight of the validation process, the laborious tasks of preparing samples, generating data, and compiling results are conducted by the contractor.

RECOMMENDATION 3:

To minimize casework disruption, a DNA laboratory should devise a proficiency testing schedule so that not all individuals are tested at the same time.

A staggered schedule will allow consistent resource allocation for casework during proficiency testing.⁷ Laboratories should purchase different proficiency test numbers from the same vendor or tests from different vendors. A mechanism for tracking the individual qualifications of analysts, reviewers, and technicians will ensure the appropriate methods and technologies are covered in each proficiency test. This tracking can be done using an Excel spreadsheet, compliance software, or a checklist worksheet that is kept in the folder for each test.

Non-Casework Support Staff

Laboratories should not overlook the staff supporting programmatic functions that are imperative to sustain operations and implement new methods and technologies. This includes training, quality assurance, and quality control (see chapter 3, section on training), the testing and validation of new methods and technologies (see chapter 5), and maintenance of equipment. Administrative support is also needed for inventory, ordering, discovery preparation, and case triage and assignment (see chapter 2). Additionally, information technology specialists are recommended to support the current methodologies used in forensic DNA analysis (see chapter 4). These functions are essential components of a successful and efficient DNA laboratory in which casework productivity remains high.

Process Efficiency and Workflow

RECOMMENDATION 4:

A DNA laboratory should engage in an independent, external, process improvement exercise to identify areas of inefficiency and maximize case output.

⁷ Scientific Working Group on DNA Analysis Methods, "The Guidance Document for the Quality Assurance Standards for Forensic DNA Testing and DNA Databasing Laboratories," 2020, https://1ecb9588-ea6f-4feb-971a-73265dbf079c.filesusr.com/ugd/4344b0_2bce9398b6a640fdb626063469939151.pdf.

A process improvement exercise relies on a team effort to improve performance by systematically removing waste within a process while maintaining quality. Exercises are data driven and result in an improvement (i.e., reduction) of the overall turnaround time for analysis. Some valuable exercises include Lean Six Sigma and Process Mapping. External exercises like these minimize bias and emotion to allow for a critical analysis of operations. An internal process improvement exercise — such as Group Decision Making,⁸ 5S Methodology,⁹ or post-report case dissection — can also help laboratories make improvements. Discussing cases as a group allows for the casework staff to identify areas where procedures can be improved and standardized.

The laboratory should identify bottlenecks and modify processes to ensure adequate and efficient turnaround times for casework. A designated staff member should examine metrics on a regular basis to adapt operations as needed. This may include the retirement of unused or underused processes or those no longer cost effective for the laboratory. For a multilaboratory system, equalizing backlogs by transferring cases or distributing technical reviews across the labs may reduce turnaround time for all cases. Consideration should be given to the number of staff, their qualifications (analyst vs. technician), and equipment (manual vs. automated processes). For example, larger laboratories may qualify only a small subset of analysts in technologies that are infrequently used (e.g., Y-STRs, mtDNA), while smaller laboratories may find it efficient to qualify all analysts in all technologies to maintain maximum flexibility. A process improvement exercise allows a laboratory to balance optimal throughput with the number of staff and equipment available.

RECOMMENDATION 5:

To maximize workflow and reduce redundancies, the laboratory should adopt a team approach to casework whenever possible.

Having dedicated staff assigned to each step of the process or to each sample type (questioned vs. known) ensures that timely results are achieved. Concurrent processing of questioned and known items in an automated fashion maximizes processing efficiency. Concurrent processing can be accomplished even if questioned and known items are analyzed by different individuals. Dedicated staff members, screeners, or technicians should be assigned specific tasks to prepare samples for DNA extraction. These tasks may include cutting swabs and placing them in extraction tubes, cutting areas positive for bodily fluids and placing them in extraction tubes, or loading plates with swab cuttings.

⁸ Donelson R. Forsyth, "Decision Making," in *Group Dynamics*, 7th ed. (Boston: Cengage, 2019), 372-408.

⁹ Michael L. George et al., "5S Overview and Implementing 5S," in *Lean Six Sigma Pocket Toolbook: A Quick Reference Guide to Nearly 100 Tools for Improving Quality and Speed* (New York: McGraw-Hill, 2004), 206-207.

Administrative staff, in conjunction with technical staff, should define the number of cases to be assigned within each batch and set a schedule for DNA processing, data analysis, and review. When laboratory management expectations are balanced with technical feasibility, realistic goals regarding processing and scheduling can be achieved.

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

"For high-priority or expedited cases, designate a single point of contact. This will ensure minimal disruption to routine casework processing."

Relying on the expertise of technicians during the testing process allows analysts to focus on interpreting data and reporting casework samples. Additionally, standardizing interpretation approaches among analysts will reduce the need for reprocessing and individual analysis preference. However, laboratories in jurisdictions that require all scientists who process a sample to testify should evaluate whether this approach truly represents an efficiency improvement.

RECOMMENDATION 6:

To effectively monitor casework operations and identify areas for efficiency improvement, DNA laboratories should define their backlog to include both unassigned cases and those that have been assigned but whose results have not yet been reported.

Understanding a laboratory’s backlog — how many and what kind of cases it contains — is essential to understanding the effectiveness of any efficiency improvements made to the laboratory’s operations. While the definition of a backlog can vary from laboratory to laboratory, NIJ defines a backlog as any cases for which a report has not been issued 30 days after the laboratory received the items for testing. Whether laboratories choose to use this definition or develop their own, the essential components of calculating a laboratory’s backlog are as follows:

- **Cases should be counted in the backlog only if the evidence is available for testing.** The evidence that a laboratory is asked to test is sometimes not available the moment the request for analysis is received. Many laboratories serve multiple law enforcement agencies and therefore require a grace period until the evidence arrives at the laboratory. Similarly, analysis by external experts may be required before the laboratory can begin DNA testing. During this time, it is not reasonable for the laboratory to be held accountable for the testing of these cases, and they should be omitted from the backlog.

"Backlogs can be a measure of customer demand as well as an indicator of the effectiveness of a process."

- **The laboratory should allow itself a reasonable time for analysis of the case before it is counted as backlogged.** Backlogs are the accumulation of untested cases. A laboratory does not have a backlog until a specific deadline is missed. Laboratories should use data to decide a reasonable time for analysis; any case requiring additional time is counted in the backlog. As noted, NIJ has set a reasonable time as 30 days. Laboratories should be aware that setting the threshold for analysis time too high defeats the purpose of a backlog metric. For instance, a 180-day analysis time may give a laboratory a small backlog number, but it most likely does not capture the true demand for timely analysis.
- **As noted in recommendation 6 above, the backlog should include cases that have already been assigned to an analyst for testing, but for which a report has not yet been written or reviewed.** It is essential to count all cases within the laboratory when establishing a backlog definition, even if analysis of some of these cases has already been completed. This allows laboratory management to detect bottlenecks at every stage of analysis — from screening and DNA analysis to report writing and review.
- **Once the laboratory issues a case report to a customer, the case should no longer be included in the backlog.**

RECOMMENDATION 7:

Laboratories should have a metrics tracking method to monitor increases or decreases in demand, laboratory analysis, turnaround times (TAT), and analyst performance.

"A word on turnaround times (TATs): Laboratories may choose to calculate multiple TATs to monitor different aspects of a laboratory's operation — for example, a TAT from evidence request to report out, from evidence receipt to report out, or from analyst assignment to report out. Like backlogs, TATs should stop once a report is issued to a customer in order to accurately measure the whole of a laboratory's processes."

For a laboratory to understand the impact of efficiency improvements and other changes to its operations, it is essential to measure the difference from a particular starting point to an ending point after a change has taken effect. This could be accomplished by having a reliable metrics tracking method. Tracking standard metrics for all cases can be used to assess:

- Case backlogs.
- Number of reports issued.
- Number of samples analyzed.
- The demand on a particular process within the laboratory (e.g., increases or decreases in the number of cases or items processed for a particular method, like Y-STRs).
- Resource allocations.
- Turnaround times.
- Budget needs.
- Individual analyst performance.

Laboratories should consider referencing Project FORESIGHT for input on what metrics may be useful to capture. Like the goal of efficiency improvement evaluations, Project FORESIGHT’s mission is to “measure, preserve what works, and change what does not.”¹⁰

Evidence Screening

RECOMMENDATION 8:

A DNA laboratory should separate the processes of evidence screening from DNA analysis in order to standardize workflow and increase the predictability of case output.

High-throughput processing is most successful when methods are standardized and inputs (i.e., evidence) are predictable. Working with stakeholders and clients on the types and number of items of evidence that will be accepted for analysis can help increase efficiency and throughput in the laboratory. (For more information on case acceptance, see chapter 2). Because serological examinations, including preservation and sampling of evidence, are time-consuming and performed on an unpredictable number and type of stain, it is difficult to develop a high-throughput evidence screening process. Nevertheless, once an item is identified and prepared for DNA analysis, the processes of extraction, quantification, and profile generation are highly standardized and predictable. These processes also lend themselves to automation and robotic instrumentation, further enhancing the ability for high-throughput analysis, whereas little to no automation can be employed during the screening process.

Dividing the laboratory staff into two branches — evidence screening (which can include Y-screening in addition to traditional serological methods) and DNA analysis — increases efficiency by allowing the laboratory to more accurately predict the number of cases it can process in a given time period. The laboratory can then determine how many cases need to be screened within that time period and dedicate sufficient staff to meet this goal. It may also help to cross-train all staff on screening and DNA processing should an excess or deficit of cases occur on one side or the other. This is especially relevant in states that have “test all” legislation, which requires that sexual assault kit evidence be processed within a defined time period.

¹⁰ “FORESIGHT,” West Virginia University John Chambers College of Business and Economics, <https://business.wvu.edu/research-outreach/forensic-business-studies/foresight>.

National Best Practices for Sexual Assault Kits: A Multidisciplinary Approach

In August 2017, NIJ and the Sexual Assault Forensic Evidence Reporting (SAFER) Working Group issued a report, *National Best Practices for Sexual Assault Kits*, with recommendations for adopting a victim-centered approach when responding to sexual assault cases.¹ The report also provides recommendations for improving support for victims throughout the criminal justice process. Chapter 5 of

the report details recommendations for processing sexual assault kits in the laboratory, advising that “laboratories should consider changing the order of processing the evidence by going to direct to DNA and then, only if needed, proceed with serology.” This recommendation mirrors that of the DNA Laboratory Efficiency Improvement Working Group.

1. National Institute of Justice, *National Best Practices for Sexual Assault Kits: A Multidisciplinary Approach*, Washington, DC: U.S. Department of Justice, National Institute of Justice, 2017, <https://www.ojp.gov/pdffiles1/nij/250384.pdf>.

RECOMMENDATION 9:

To decrease sample processing time and maximize laboratory resources, a DNA laboratory should adopt a Y-screening and/or direct to DNA approach for screening evidence samples for DNA.

The serology tests employed by forensic DNA laboratories are time-consuming and less sensitive than modern DNA typing kits. In addition, if DNA typing is performed only on swabs that screen positive in serology tests, analysts may miss DNA profiles from body fluids not tested by a laboratory or samples collected for “touch DNA.” Rather than using traditional serology to determine which swabs should move forward to DNA analysis, we recommend using a Y-screening or direct to DNA approach, or a combination of both.

Most evidence types are amenable to these testing methodologies, and they are especially useful for sexual assault kits (SAKs). Most SAKs contain a single, common method of collection (e.g., swabs) from various body sites. The need to locate potential stains for testing has been removed, and all swabs have the potential to be Y-screened upfront. Conversely, a sheet or item of clothing may require manual examination prior to considering Y-screening. For example, consider using an alternative light source initially, followed by acid phosphatase testing, to identify which stains to Y-screen.

Laboratories should also consider validating specific quantification cutoffs to determine when a sample should proceed directly to autosomal or Y-STR amplification, be re-extracted (e.g., when a differential protocol may yield a stronger male profile in the secondary fraction), or be terminated altogether (e.g., where the Y quantification value is undetermined or below a validated threshold):

What Are Y-Screening and Direct to DNA?

In certain cases, such as those involving female victims, the detection of male DNA can be critical to the subsequent processing of a case. Screening samples for a Y chromosome followed by amplification of select DNA extracts is a methodology that allows for the quick, efficient extraction of a sample followed by quantification to determine the presence or absence of male DNA (i.e., Y-screening) and the potential to generate a DNA profile with that same extract (i.e., direct to DNA). Modern

quantification kits also have the ability to assess the quality of DNA from a particular sample, enabling forensic analysts to predict the quality of the DNA profile and allowing them to ascertain if direct to DNA is the best option for the sample, or if it may require additional purification or re-extraction. Moreover, in cases where multiple samples are processed, this approach can assist analysts in determining which samples are more appropriate for downstream processing.

- A direct to DNA approach allows laboratories to proceed directly to autosomal amplification without re-extraction:
 - Probabilistic genotyping tools such as STRmix, True Allele, or Lab Retriever can be used to deconvolute potential mixtures.
 - There is also the potential to cause the owner to further assist in deconvolution.
- When the ratio of female DNA to male DNA would not generate an interpretable autosomal profile from the male component, a direct to DNA approach allows laboratories to proceed directly to Y-STR amplification.
- When the presence of female DNA is not high enough to completely obscure the male profile, but may cause portions of the profile to drop out, a direct to DNA approach allows laboratories to decide if re-extraction with a differential extraction protocol would be more beneficial to certain sample types.
- The validation of a stopping point at a Y quantification threshold during Y-screening allows laboratories to discontinue the DNA process on samples for which the analyst has a reasonable expectation that a female donor would be expected in an evidence profile (e.g., swabs collected in a SAK from a female victim) or for which the amount of Y DNA detected is below the threshold for obtaining an interpretable male DNA profile.

Laboratories should develop strategic guidelines to assist analysts in selecting samples for additional testing, potentially limiting the number and types of samples to avoid unnecessary analysis. Consideration should be given to case scenario (e.g., number of perpetrators/suspects), location of sample (e.g., intimate vs. nonintimate), and quantification information (e.g., quantification value and quality indicators).

Some forensic DNA laboratories elect to process all samples contained in a sexual assault kit through a differential extraction process upfront, forgoing traditional screening protocols. This eliminates the need for potential re-extraction when Y-screening methodologies are employed. If this approach is adopted, the use of automation is critical given the laborious nature of differential extractions.

RECOMMENDATION 10:

To decrease analysis time and reduce sample consumption, traditional serological testing and sperm searches should be conducted only when necessary.

Serological testing consumes evidence, and many of these tests are presumptive and less sensitive than current DNA typing methods. Viable investigative leads can be provided using DNA analysis without the need for body fluid indication. For example, a suspect's shirt with multiple apparent bloodstains will be more efficiently screened with a Y-screening/direct to DNA approach, which can be used to triage stains carried through to DNA profile generation. In this example, the absence of a Y quantification can indicate a female victim's DNA on the male suspect's shirt.

Although sperm searches are confirmatory, manual sperm searches remain one of the most time-consuming and laborious analyses during the evidence screening process. In conjunction with Y-screening, the necessity of identifying spermatozoa on a sample becomes less crucial to downstream DNA processing. Laboratories employing Y-screening should consider omitting slide preparation and sperm searches as a standard practice during their initial analysis. Instead, they should conduct sperm searches only by customer request.¹¹

DNA Testing: Automation and Batching

RECOMMENDATION 11:

To decrease time spent performing bench work, a DNA laboratory should employ automated techniques in the DNA processing steps whenever possible.

Robotic solutions come in a variety of sizes and can handle varying numbers of samples in one run. Using vendor software or Excel

¹¹ National Institute of Justice, *National Best Practices for Sexual Assault Kits: A Multidisciplinary Approach*, Washington, DC: U.S. Department of Justice, National Institute of Justice, 2017, 58, <https://www.ojp.gov/pdffiles1/nij/250384.pdf>.

worksheets to automate the creation of instrument-specific files for the robotic software and to track samples throughout the DNA workflow can increase efficiency as well as quality.

Automation of sample preparation for quantitation, amplification, and capillary electrophoresis will also decrease time spent by analysts on these routine tasks, freeing them for higher-level tasks such as DNA interpretation and report writing.

RECOMMENDATION 12:

To decrease the time spent and number of analysts/individuals performing bench work, the laboratory should employ batching at each step of the DNA process.

A batch is a set of samples from multiple cases that are processed together by one or more analysts. Some examples of batching include:

- One analyst takes multiple cases through the DNA analysis workflow.
- Multiple analysts run their cases together on the instrumentation.
- Analysts extract their own samples, and then a single individual performs the subsequent steps (quantitation, amplification, and capillary electrophoresis) for multiple analysts' samples. The analysts then interpret and report their own assigned cases.
- One person runs the instrumentation for multiple samples or cases at a given step.
- Known reference samples from multiple cases are processed together by a separate team or group (e.g., databasing).

Monitoring Performance

RECOMMENDATION 13:

A DNA laboratory should implement a method for regularly evaluating the functional elements of the laboratory in order to ensure quality, monitor growth, and avoid process decline.

Throughout this document, recommendations put forward changes that laboratories can make to achieve tangible improvements in efficiency. Laboratories cannot expect, however, that enacting one or more recommendations will produce immediate, long-lasting results. Maintaining and building on these recommendations is essential for creating results that will endure. Laboratories need to identify key elements of their processes, assign responsibility

for those elements to a manager, TL, or analyst, and monitor the processes to ensure that performance improvements are sustained over time and meet the laboratory's short- and long-term goals.

For example:

- Regular reviews of the laboratory's evidence submission policy (see chapter 2) should be conducted not only to ensure compliance, but also to assess the present policy's effectiveness with respect to the capacity of the laboratory.
- A periodic (e.g., monthly) review of laboratory metrics may reveal opportunities for improvement in specific areas without increasing staffing levels or may identify the sources of bottlenecks, justifying the need for additional support.
- Stakeholder trainings should be conducted at regular intervals to ensure the laboratory's customers understand reporting language, submission policies, and the kinds of testing their laboratory offers.

However a laboratory chooses to monitor its effectiveness, the details of that monitoring (who, what, where, and when) should be formally documented. A thorough monitoring plan includes the process or metric to be monitored, how often it should be monitored, what actions to take, when to take them, and who is responsible for them.

Accepting the Case: Evidence Submission, Request Prioritization, and Stakeholder Training

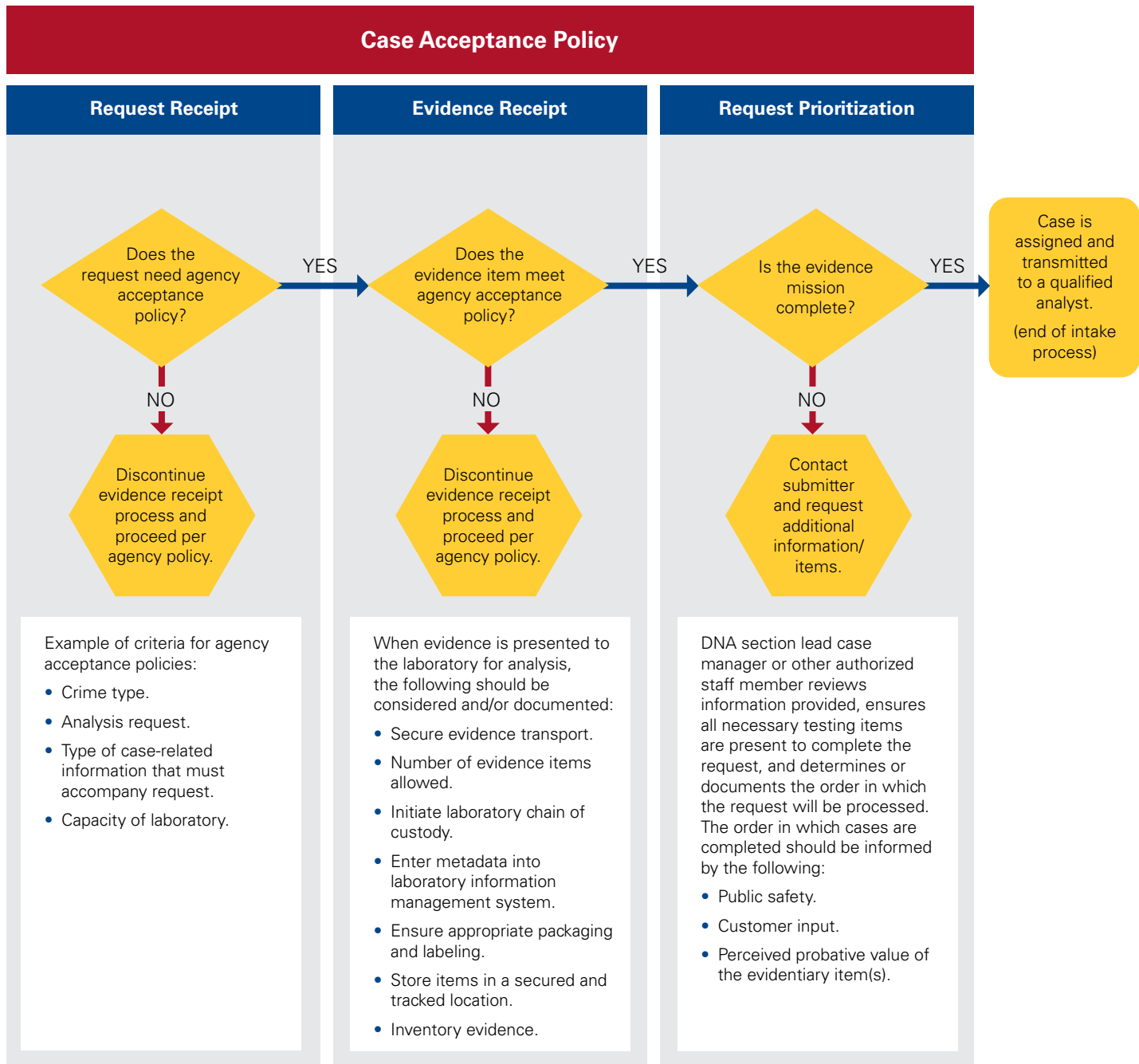


The first chapter of this guide reviewed the functions of the laboratory's management and operations team, which is responsible for keeping the laboratory running smoothly. Even the very best management and operations team, however, cannot improve the efficiency of a DNA forensic laboratory and effectively manage caseloads if the laboratory lacks a clearly defined case acceptance policy. This policy establishes the standard requirements for the routine submission of evidence to the laboratory and is composed of guidance in the following areas: request receipt, evidence receipt, and request prioritization. A well-designed policy can reduce the number of samples submitted and thereby reduce the laboratory's caseload. In tandem with a clear case acceptance policy, the laboratory should have clear evidence submission and criteria-based prioritization guidance in place to direct the timely processing of cases to meet legislative, investigative, and capacity-based demands. The case acceptance policy sets the rules of engagement surrounding a laboratory accepting responsibility to perform and report scientific analysis on evidentiary items. A complete case acceptance policy contains guidelines on topics such as evidence acceptance and prioritization.

To respond efficiently and appropriately to requests for DNA analysis, a forensic DNA laboratory should adopt a clear and easily accessible case acceptance policy. Once the laboratory accepts a case, it must consider the submitted items and evaluate the importance of the case in relation to the overall caseload in order to return investigative information in a timely manner. Adopting clear policies for case acceptance, including evidence submission and case prioritization, may shorten turnaround times and reduce backlogs.

As a prerequisite to case acceptance, the laboratory should educate stakeholders on key aspects of the policy (e.g., identifying the items that are most likely to yield informative results) to limit the number of items submitted and ensure stakeholders understand their role in the process. When stakeholders submit only the most promising subset of items, the laboratory can work to expedite the reporting of forensic testing information from those items while conserving resources.

EXHIBIT 1. ACCEPTING A REQUEST



Note: This is a workflow diagram that depicts the basic steps involved in accepting an analysis request from a law enforcement contributor. Each pillar represents a major milestone the lab will need to consider as it undertakes responsibility for accepting a case.

The recommendations in this chapter help establish guidelines for what items should be submitted to the laboratory, the order in which they should arrive for analysis, and the order in which they should be assigned for testing within the laboratory.

Current submission practices vary widely among agencies and laboratories based on elements such as:

- Experience of the submitting officer.
- Size and resources of the submitting agency.
- Case type (violent vs. nonviolent crime).
- Amount of evidence collected.
- Pending trial date.
- Potential for investigative leads in cases with public safety concerns (e.g., violent crimes lacking a suspect).
- Pressure from prosecutors' offices, judges, courts, media, and the public.
- Legislative mandates.

Whether laboratories will accept evidence submissions depends on such elements as:

- Laboratory's current volume of submissions.
- Previous testing and results in the case.
- Number of agencies a laboratory serves.
- Data-driven evaluations of testing results and success rates.
- Existing submission guidelines or lack thereof.
- Mode of incoming submissions (i.e., common carrier or in person).
- Legislative mandates.
- Laboratory's size and resources (e.g., number of analysts, experience of staff, available equipment).

The strategy a forensic DNA laboratory adopts for prioritizing cases is influenced by many factors, which differ based on jurisdiction and are often driven by circumstances beyond the laboratory's control. These factors include:¹²

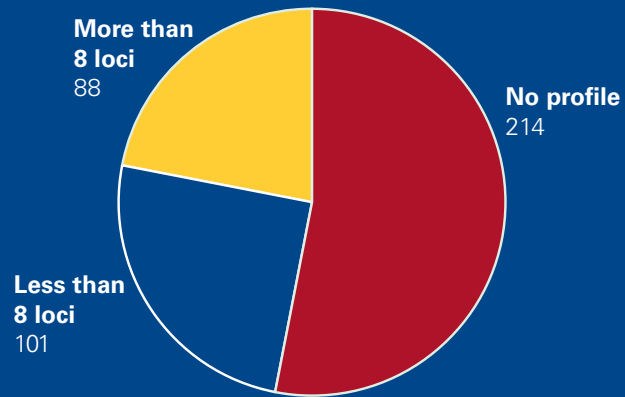
- Pending court dates or requests from a court official.
- Immediate concern for public safety.
- Case information, including database matches.
- Legislative priority.

¹² Arkansas Division of Legislative Audit, "Case Prioritization and Turnaround: Arkansas State Crime Laboratory," Special Report to the Arkansas Legislative Joint Auditing Committee, April 10, 2009, <https://projects.nfstc.org/fse/pdfs/PSSR06609.pdf>.

Example of a Data-Driven Acceptance Policy Decision That Improved Laboratory Efficiency

In 2011, after the first major legislation on sexual assault kit (SAK) testing became law, laboratories in Texas were forced to evaluate their efficiency. The legislation mandated that law enforcement agencies submit sexual assault kits within 30 days of collection to the lab for testing, along with an additional legislative requirement to test all SAKs going back to 1996. As a result, laboratories in Texas saw a sudden and dramatic increase in the number of cases they had to process — yet even before the legislation, they were struggling to complete analysis on cases in a timely manner, and most carried backlogs.

As a way of evaluating efficiency, one laboratory assessed the testing results of evidence submitted for touch DNA analysis. Using a laboratory information management system, the laboratory identified a particular subset of cases from 2008 to 2011: those for which the submitted evidence contained no body fluid and an attempt was therefore made to develop a profile from skin cells left behind when the evidence was handled. The laboratory identified 201 such cases and reviewed a total of 403 DNA profiles. Profiles were placed into three categories: no profile; profiles with fewer than 8 loci, the minimum number needed for entry into the Combined DNA Index System (CODIS) at the state level; and profiles with more than 8 loci.



The results showed that 78% of profiles obtained from touch DNA analysis resulted in data unsuitable for entry into CODIS. In particular, none of the bullets or cartridge cases analyzed for DNA yielded a CODIS-suitable profile. In response to this finding, the laboratory completely stopped processing bullets and cartridge cases for DNA. This resulted in greater efficiency for the laboratory, as it allowed the staff to focus their efforts on cases that were more likely to yield DNA profiles.

- Offense type.
- History of the case (i.e., for requests of similar case type, the criteria for expedited analysis of one request over another should be determined).

Process efficiency improvements that target evidence submission and case prioritization practices may directly impact overall testing delays and reduce bottlenecks. Laboratories may hold case review meetings with the submitting agency to prioritize evidence items for testing in specified case categories (e.g., violent crimes) or to preapprove all submission and prioritization requests. The review meetings may be in person or by telephone, or the reviews may occur entirely through electronic submission request forms. This level of case management may not be feasible for laboratories with limited resources, facilities servicing an entire statewide network of submitters, or in instances in which an in-person discussion is not possible or required prior to evidence drop-off.

Laboratories should use data-driven and experience-based DNA success rates in selecting evidence items to process,¹³ prioritizing the analysis of the items within a case,¹⁴ optimizing the number of items to be tested in a case,¹⁵ and determining the relative importance of the case compared to others in the queue.

Training law enforcement officers and other stakeholders to identify the most promising items for analysis can mean less time spent on casework in the laboratory. Thorough training materials that can be reused or made available for self-education will address the knowledge gaps created by turnover among stakeholders, although creating these training materials may require significant upfront investment. Laboratories should conduct periodic training sessions for stakeholders to address new policies and new technologies as they are implemented. Whenever possible, laboratories should also collaborate with each other on training materials and resources to promote consistency in the forensic laboratory community; however, training should be customized to the particular needs of each laboratory. The laboratory should consider getting input from its stakeholders about the most effective means of training for the intended audience. A good training module allows stakeholders to make informed choices about their submissions and requests, enabling the laboratory to conduct its analyses more effectively and efficiently.

Evidence Submission

RECOMMENDATION 14:

Every forensic DNA laboratory should have documented evidence submission guidelines, including a detailed list of submission requirements (e.g., limitations on the number of items, in accordance with offense type) that is clearly communicated to submitting agencies. (See appendix A for an example policy.)

The forensic DNA laboratory's policy for evidence submission should be based on an assessment of its testing capabilities, resources, and success rates for each item type (e.g., blood stains vs. contact DNA). The policy should outline the minimal requirements for evidence submission, including case information, allowable item types, and number of items permitted for testing. These requirements should be specific to each

¹³ Anna A. Mapes et al., "Knowledge on DNA Success Rates Optimized the DNA Analysis Process: From Crime Scene to Laboratory," *Journal of Forensic Science* 61 no. 4 (2016): 1055-1061.

¹⁴ Simon Baechler, "Study of Criteria Influencing the Success Rate of DNA Swabs in Operational Conditions: A Contribution to an Evidence-Based Approach to Crime Scene Investigation and Triage," *Forensic Science International: Genetics* 20 (2016): 130-139.

¹⁵ Naftaly Einot et al., "Reducing the Workload: Analysis of DNA Profiling Efficiency of Case Work Items," *Forensic Science Policy & Management* 8 (2017): 13-21.

case category (e.g., homicide, burglary, sexual assault), and examples should be provided. In addition to limiting the number of items that can be submitted, the policy should also stipulate that the stakeholder is responsible for prioritizing those items prior to submission. This will streamline analysis, allowing the laboratory to provide a timely response to requests and limiting redundant or uninformative testing.¹⁶

RECOMMENDATION 15:

Laboratories should consider a tiered approach to evidence submission both as a means to control the amount of evidence coming into the laboratory and the amount of testing conducted within a case. This approach will shorten the turnaround time between submission and the final report.

With a tiered approach, the first submission of evidence to the laboratory should be limited to items that may either identify the perpetrators or provide enough information for probable cause to arrest and hold the perpetrators (e.g., a sexual assault kit in a rape case). Limiting the first round of testing allows the laboratory to streamline its analysis and identify a probative profile, thus enabling a quicker entry into CODIS and more rapid reporting.

The client may find that this first-tier information is sufficient, obviating the need to submit additional evidence (e.g., victim clothing, bedding, suspect clothing, swabs from the scene) to the laboratory. If, however, the client deems it necessary to submit further evidence, the client should make this second-tier submission in consultation with the laboratory. Together, the client and the laboratory can triage the additional evidence and decide which is appropriate to submit. Factors to consider include whether the suspect was known to the victim, whether the suspect and the victim had a previous relationship, and whether the suspect previously visited the crime scene. Second-tier requests for analysis should aim to answer questions relevant to the case that the first-tier testing did not answer.

As part of its evidence submission guidance, the laboratory may include a “right of refusal” that sets clear standards for sample submissions. For example, a requirement for securing and disabling firearms, or for including photographs of evidence intended for analysis, can help agencies avoid errors when they submit samples for DNA testing. The laboratory can also streamline the submission process by requesting that all information and reference samples be provided before or at the time of submission. For examples of forensic DNA laboratory submission policies, see appendix B.

¹⁶ Wickenheiser, Forensic Laboratory Efficiency and Funding (2013), Encyclopedia of Forensic Sciences, <https://www.sciencedirect.com/science/article/pii/B9780123821652000635?via%3Dihub>.

Considerations for Creating Evidence Submission Guidelines

- The laboratory should consider its resources, capabilities, and limitations when establishing guidelines.
- The policy must be clearly defined to include requirements for accepted evidence, evidence not accepted, evidence typically not accepted, and exceptions to the policy.
- Exceptions to the policy, if allowed, must be defined and based on specified case types and case scenarios to ensure consistent compliance.
- The policy must be documented and accessible to all users.
- The policy must be understood by all users. Staff should be trained to consistently and appropriately apply the policy's requirements and limits.
- Staff who make decisions about evidence submission — including directors, administrators, managers/supervisors, analysts, and technicians — should have the opportunity to provide input about the policy.
- The policy should define case types/scenarios (e.g., multi-item submissions) that require pre-submission consultation.
- The laboratory should establish a subset of individuals trained to perform case reviews/ consultations.
- Individuals who perform case reviews/ consultations must understand laboratory prioritization policies and be trained in identifying a subset of probative evidence to be submitted for first- and second-tier testing.

RECOMMENDATION 16:

To collect pertinent case information and reinforce the laboratory's policy, the evidence submission process should include a standardized, web-based form for initiating a submission request.

The laboratory's web-based request form should be fully tested and implemented in a way that all stakeholders can readily access (e.g., the form is available for download from the laboratory's public website or otherwise electronically accessible to the stakeholder). At a minimum, the form should capture detailed, case-specific information (e.g., CODIS eligibility information), forestall the submission of more than the allowable number of items, and enforce the requirement for necessary reference and elimination samples. The status of the request (e.g., accepted, rejected with reason provided, more information needed, references needed) should be communicated and documented.

RECOMMENDATION 17:

The laboratory should have a method for reviewing submission requests and providing consultation, when necessary, prior to acceptance to assist submitters' selection and prioritization of items.

As dictated by case circumstances, the laboratory should consult with the submitter prior to submission acceptance. For example, in

cases with particularly large volumes of evidence (i.e., above limits defined by laboratory policy), the consultation provides an opportunity for the laboratory to set clear expectations on prioritization of item processing and secure the submitter’s agreement in advance. The laboratory should establish a single point of contact for consultation requests, such as a case management email inbox.

Science staff performing casework should not be the initial point of contact for pre-submission consultations, nor should they be involved in the day-to-day communication required to ensure all evidence is available and ready for testing. This allows the scientists to focus primarily on analysis with minimal disruptions.

RECOMMENDATION 18:

A laboratory should designate an individual or team to ensure the consistent application, enforcement, and accountability of the evidence submission guidelines to prevent acceptance of noncompliant submissions and unnecessary disruption to analysts.

Enforcing the requirements in the acceptance policy, specifically the item submission limits, will permit laboratories to maintain consistent testing turnaround times and prevent exponential backlog growth. The individuals responsible for case management and consultation are likewise responsible for communicating and enforcing the acceptance policy. Their effectiveness is based on their understanding of the laboratory’s testing capabilities, realistic testing time frames, and prioritization of testing requests.

Case Prioritization

To increase the efficiency of assigning and processing cases, laboratories should have a dedicated individual, or team of individuals, responsible for the intake and prioritization of DNA case requests. Keeping the task of prioritization centralized will maintain the consistency of prioritization levels and the order of cases within the assignment queue. To maximize throughput, staff performing casework should not be involved in this function. While requests for priority stem from the stakeholder, they must be vetted by the laboratory and both parties must agree on the appropriate priority designation.

RECOMMENDATION 19:

Laboratories should have written, clearly defined case prioritization guidelines that laboratory staff can consistently apply. This will eliminate unnecessary interruptions that delay testing.

Formally documented case prioritization guidelines are a written set of standards to which personnel can refer when questions arise. Effective prioritization policies include details such as:

- Types of cases and their prioritization rank.
- How a request for expedited analysis is made.
- Which types of justification must be given for higher prioritization.
- How to track the progress of testing (e.g., assigning priority codes using the laboratory's information management system) to allow progress to be efficiently communicated to stakeholders and minimize interruptions of the analysts.

RECOMMENDATION 20:

Laboratories should designate and train personnel who are responsible for prioritizing cases. This ensures compliance with the policy, preventing unnecessary disruption to analysts and shortening overall laboratory turnaround time.

Laboratory personnel responsible for vetting cases and processing requests for expedited analysis must understand the case prioritization guidelines as well as the reasons behind the policy so that they can make informed decisions about moving cases within the queue. Personnel assigned to prioritize cases should be educated on:

- Laboratory capabilities.
- Capacity.
- Relevant case acceptance policies.
- Requirements for completing analysis.
- Time required for analysis.
- Impact of requesting analysis from multiple forensic disciplines.

With this knowledge, the assigned staff can clearly inform submitters why their requests were accepted or rejected, with the goal of ensuring that future requests comply with the case acceptance policy. The success of the prioritization guidelines depends on the laboratory's ability to adhere to them with minimal deviations.¹⁷ Allowing deviations undermines the process because this effectively changes the order of all the other cases in the queue. Constant changing of the policy can be highly disruptive, increasing turnaround time for in-progress cases, interrupting workflow, fostering inefficient use of resources that also increases costs (e.g., for

¹⁷ Anna A. Mapes et al., "Knowledge on DNA Success Rates Optimized the DNA Analysis Process: From Crime Scene to Laboratory," *Journal of Forensic Science* 61 no. 4 (2016): 1055-1061.

personnel, reagents, equipment), and increasing the risk that low-priority cases become high priority as the time lag between submission and analysis increases.

RECOMMENDATION 21:

Requests for expedited analysis should be reviewed and approved by a limited number of laboratory management personnel to ensure consistent application of policies.

Laboratories can be inundated with requests for expedited analysis related to evidence submission and case prioritization and should develop policies to address how these requests are to be handled. Inconsistent application of policies can lead to stakeholders “shopping around” for higher prioritization of their submissions. Failure to uniformly apply a policy can cause confusion among laboratory staff and stakeholders in addition to the appearance of bias, especially if a decision is appealed to higher management and ultimately overturned. Creating a clear-cut policy that everyone can follow and limiting the number of management personnel who can review and approve requests for expedited analysis will help ensure consistent application of the policy. Laboratories should be prepared to address requests for expedited analysis in a manner that ensures consistency, remembering that exceptions can shape future expectations. Requests for exceptions should be in writing, and approval of these requests should be documented in the case record.

Multiple high-priority requests from different individuals within the same agency can strain a laboratory’s resources, especially when the parties are unaware of each other’s requests. The laboratory may consider asking the agency to establish a consistent point of contact who understands the laboratory’s capabilities and has the authority to sort the agency’s requests according to their priority within the agency.

RECOMMENDATION 22:

The laboratory should conduct a periodic review of the policy to evaluate its effectiveness, whether stakeholder needs are being met, and whether modifications are warranted.

A policy can be effective only while it is relevant. When stakeholder needs and laboratory capabilities evolve, the case acceptance policy must evolve as well. Feedback from customers is necessary to ensure the policy is having the desired effect and is providing relevant guidance.

Stakeholder Training

DNA analysis is a constantly changing discipline fueled by new technology. The services that forensic laboratories offer in this evolving

Stakeholder Needs Can be Assessed by:

- Surveys.
- Metrics.
- In-person meetings.
- Informal communications.

field depend on each individual laboratory's budget, personnel, and backlog. While DNA examiners are expected to keep up with advances in technology, it is just as important to educate and inform the stakeholders who make decisions about evidence submission and requested examinations. Because of significant turnover within stakeholder agencies, their personnel need continual training regarding DNA laboratory acceptance and prioritization policies, procedures, and capabilities. This section offers recommendations about fostering open and continuous communication between the forensic DNA laboratory and stakeholders in a manner that preserves productivity.

To function efficiently, laboratories have developed policies to control the flow of evidence into the laboratory and subsequent prioritization of requests. In the past, these policies have been communicated through printed fliers, emails, or websites. Fliers may get tossed aside, emails can be overlooked, and even if the information reaches the target audience, it may be ignored if it does not offer a clear explanation of the laboratory's policies. Some laboratories rely on outside training tools or resources in an effort to preserve examiners' time. This may result in unintended confusion, however, if the training materials discuss technology or practices not in use by the laboratory. Many laboratories train law enforcement agents, attorneys, judges, and nurses; the demand for training is usually greater than capacity.

RECOMMENDATION 23:

The laboratory should train stakeholders about its scientific capabilities, policies, and procedures, and provide periodic updates as necessary. Ensuring that stakeholders have an up-to-date and clear understanding of laboratory operations minimizes unnecessary questions that distract the analyst and disrupt laboratory workflow.

Whenever the laboratory implements new policies or capabilities, it must provide consistent training and enforcement. This can be accomplished either in a formal training session or by designating laboratory personnel to communicate with stakeholders either before or during evidence submission or during pre-trial discussions with attorneys. Some laboratories have even established training programs for judges, defense attorneys, and prosecutors.

New guidelines and policies are more likely to be accepted when their audience knows that its interests were represented in the design process. Including stakeholders in discussions about establishing the guidelines or policies helps the laboratory to consider all perspectives, and early input lowers the likelihood that something will be overlooked, reducing the need for later policy modifications. Stakeholders are also more likely to understand and accept a policy when they understand the impact and potential benefits of compliance. For example, if officers understand that implementing a two-item maximum on property crime submissions will significantly shorten processing time, they are more likely to comply with the policy.

A list of Frequently Asked Questions (FAQs) can be helpful, especially if policy training is being conducted remotely without a moderator. Content should include information about turnaround times, interlaboratory case transfers, laboratory command structure, and who to approach for consideration of exceptions. FAQs can easily be updated as policies change.

If a new policy dictates that evidence must be in a certain condition (e.g., paper packaging, air-dried, marked as “unloaded”), the training should include explicit instructions, video, or a demonstration to describe how to achieve the condition. For example, if the laboratory policy dictates that swab evidence is the only evidence accepted for property cases, the training must include directions for how to swab evidence. If the laboratory policy mandates that evidence must be air-dried before submission, the training must include directions for how to adequately air-dry evidence.

Training should also take into account whether the submitter is the case officer or an agency courier. Law enforcement departments may have policies regarding the authority of unsworn or courier employees to make decisions on cases at the time of submission. The laboratory should make clear that if decisions are needed at the time of submission, the submitter (whether the case investigator or courier) must be prepared to make the decision, contact someone who can make the decision, or withdraw the submission.

RECOMMENDATION 24:

Laboratories should develop innovative and effective means for training and educating stakeholders.

Stakeholder training can be accomplished through interactive, demonstrative, and reference materials, ensuring the material is understood and that stakeholders are more likely to comply with laboratory policies.

As the intended audience, stakeholders should be encouraged to participate in efforts to develop the most effective means of delivering training.

The traditional means of training — fliers, pamphlets, and emails — are passive, lacking a feedback mechanism to ensure the reader comprehends the content. If these methods are used to educate customers, every effort should be made to develop user-friendly materials. Such materials may include:

- Copies of mock submission forms.
- Pictures of properly sealed evidence.
- Flow charts of DNA laboratory chain of command.
- List of steps for swabbing an item of evidence.
- List of case types and evidence accepted.

Materials in this form of training can be easily transported between office, crime scene, court, and other locations for reference or review. This allows laboratory personnel who are receiving evidence to more easily enforce guidelines and educate stakeholders about the laboratory's policies by having ready access to the material at evidence-receiving areas.

PowerPoint slides or videos¹⁸ provide a more active training experience for individuals who are visual or auditory learners. Digital training aids can be saved and referenced on a cellphone at the crime scene or other location. Supplementing slides or video with a written handout provides a “cheat sheet” for participants if cellphone use is not practical.

Many laboratories have found that interactive training, in-person or with webinars, has the greatest impact. In such training, individuals not only get immediate answers to their questions, but the entire audience benefits from the shared answers. In-person training, including swabbing exercises, enables participants to learn hands-on under the guidance of the instructor. Of course, such training has a limited ability to reach the entire audience of stakeholders simultaneously; not all stakeholders can attend an in-person training at a given location and time. While other training materials can be recycled, this form requires human delivery.

In selecting the mode of training, the laboratory must consider the intended size and composition of its audience, the extent of training needed (e.g., announcement, “how to” training), and the laboratory resources available. Training content for a law enforcement audience will likely be different from training intended for officers of the court. Participants must be held accountable for the content, either by acknowledging receipt of the training or by successfully completing a quiz at the end of the training.

¹⁸ For example training videos, see <https://houstonforensicscience.org/how-to-videos.php>.

Stakeholder Communication

RECOMMENDATION 25:

Laboratories should develop effective communication with all appropriate stakeholders to ensure timely discussions and decisions regarding case analysis. Implementation of effective communication mechanisms throughout the process can eliminate unnecessary interruptions that can strain a laboratory's resources and delay testing.

Communication with stakeholders may begin before case submission and extend beyond the issuance of a report, spanning topics such as disseminating new policies, confirming case details, clarifying discrepancies, clarifying the relevant charges in the case, discussing case status and priority, communicating court dates, querying the meaning of reports, and confirming subpoena dismissals. This communication can take many forms, including in-person meetings, phone or video calls, emails, case reports, and testimony.

Depending on its resources, the laboratory can designate specific individuals as case managers; these case managers will serve as the conduit between the stakeholder and the laboratory analyst, communicating essential information while minimizing interruptions to the analyst. Alternatively, laboratory staff can communicate with stakeholders through voicemail and email, which also allows the analyst to work uninterrupted on casework. Email has the advantage of also serving as documentation of an exchange, and it does not require recipients to be immediately available. Emails should always include case identifiers (e.g., agency case number and laboratory case number), ensuring all parties can identify the correct case without violating any information security policies regarding personally identifiable information. Emails should include directions about what to do if the message is received by the wrong party as well as disclaimers that documentation will become part of the case file and could be discoverable. Read receipts can signal the sender that the email was successfully delivered. Any exchanges of information conducted by phone or video must be transcribed for case file documentation.

Laboratory staff must make sure they are communicating with the appropriate stakeholders. Valuable time can be lost if case decisions or priorities are discussed with individuals who do not have the background or authority to contribute to the decision, too many individuals are involved, or the discussions are repetitive or interruptive. Daily calls to the laboratory about case status can be intrusive and counterproductive.

Both laboratory case managers and the stakeholders who submit evidence should have a clear understanding of the laboratory's capabilities, relevant case acceptance policies, requirements for completing analysis, time required for analysis, and the impact of requests for analysis from multiple forensic disciplines.

Staffing: Hiring, Training, and Retention



With a group of well-qualified managers and leaders in place and policies on submission and prioritization clearly stated, there is another critical element that is sometimes overlooked: hiring, training, and retaining an expert staff.

Employees form the backbone of any DNA forensic laboratory. The efficiency with which a DNA laboratory operates ultimately depends on the quality and coordination of the staff. Nevertheless, many laboratories have hiring restrictions put in place by government administrations, or are subject to legislation that negatively affects their staffing efficiency. This chapter opens a dialogue with stakeholders to address the limitations — financial and otherwise — that hinder the ability of forensic laboratories to hire and train personnel.

It also discusses best practices for recruiting, hiring, training, and retaining a high-quality staff whose members work well together and can handle the demands for precision and timeliness that are part of working in a modern DNA forensic laboratory. Recruiting, hiring, and training forensic analysts is an arduous and complex process, the outcomes of which will directly impact the laboratory's functioning and efficiency.

Recruiting and Hiring

Laboratories face many challenges in hiring new staff. The competition for talent can be high, and many laboratories find they are not attracting interest from well-qualified candidates. In addition, slow hiring processes, restrictive human resource requirements, and reactive hiring (i.e., seeking to fill a position only after it has been vacated rather than anticipating recruiting needs ahead of time) can further limit a laboratory's ability to recruit the best candidates. Many of the most highly qualified candidates appear on the job market infrequently, so it would benefit laboratories to plan ahead in their efforts to recruit.

RECOMMENDATION 26:

To increase the pool of qualified candidates, laboratories should establish outreach programs that market careers in forensic DNA testing to students.

Many applicants seeking employment in forensic DNA laboratories are disqualified or rejected based on a lack of academic qualifications or a personal history that includes drug use, a criminal conviction, or financial delinquency. As a result, laboratories with a small pool of candidates may find it difficult to fill vacancies in a timely and cost-effective manner.

By using university job fairs to promote careers in forensic science, the laboratory can directly communicate to the candidate pool which coursework, degrees, and laboratory experience will help them gain employment. In addition, reaching out to local high schools and participating in career days there can generate interest even before the potential candidates begin pursuing college degrees.

Every year, National Forensic Science week draws attention to the field. Some laboratories use this time to invite local students to tour their facility and introduce them to forensic science careers. To reach an even younger audience, laboratories have collaborated with elementary and middle schools to develop science curricula that include the forensic disciplines.

RECOMMENDATION 27:

To increase efficiency through staffing, laboratories should consider using non-agency funding as a stop-gap measure until permanent agency funding is available.

Forensic laboratories face challenges in balancing backlogs with budgetary constraints. Often, backlogs can only be tackled by adding personnel. Without a dedicated budget for expanding staff, laboratories must seek creative solutions for hiring that will improve productivity and efficiency. For example, a laboratory could use grant funds to immediately hire temporary staff. The laboratory would then have time to solicit additional funding for a permanent position and justify the need for the position based on the increase in the workload per individual.

Some local and regional laboratories are having success with shared services programs. Laboratories can establish a memorandum of understanding with local agencies and receive funding to hire new personnel who process specific types of cases or cases from a particular agency. The laboratory benefits from the additional personnel and the

Creative Hiring Solutions

Increasing the number of support staff may sometimes be a more cost-effective and faster way to improve efficiency than focusing solely on hiring more DNA analysts. Technicians, case managers, or administrative assistants can take on some of the

extra tasks that analysts may be performing so that they can devote more of their time to casework. Because support staff can typically be trained faster than analysts, added support staff can make an impact more quickly after being hired.

A Collaborative Approach to Increasing Laboratory Efficiency

The Palm Beach County Sheriff's Office Forensic Biology Unit used a collaborative approach to decrease their backlog: They opened a centralized biological processing laboratory to screen samples prior to submission to the DNA laboratory. By

establishing law enforcement partnerships through multiagency agreements along with the use of grant funding, the biological processing laboratory helped the Forensic Biology Unit decrease turnaround times and offer faster communication of test results.

Source: Cecelia A. Crouse et al., "DNA Backlog Reduction Strategy: Law Enforcement Agency Partnerships for a Successful Biological Screening Laboratory," *Forensic Science International: Synergy* 2 (2020): 24-31, <https://doi.org/10.1016/j.fsisyn.2019.11.001>.

reduced turnaround time on casework. This type of program promotes interagency cooperation on casework.

RECOMMENDATION 28:

To increase the pool of potential employees, laboratories should offer volunteer opportunities and internships in partnership with forensic science academic programs.

Laboratories review credentials and conduct interviews to select qualified candidates, but it can be difficult to evaluate candidates' ability to perform the full scope of the job until they are hired and trained. Laboratories often expend many hours and resources to hire, onboard, and train a new staff member, only to realize that the employee is not the right fit for the position or agency. One solution is for laboratories to offer internships in partnership with forensic science academic programs; internships aid in recruitment and also allow laboratories to evaluate the abilities of prospective hires on the job. The intern benefits by gaining job-related experience and a foothold with a potential employer; the forensic laboratory benefits in the short term by assigning the intern meaningful projects that contribute to the laboratory's daily operations, and in the long term by establishing a pipeline of potential employees whose abilities are already verified.

Even if the laboratory cannot accommodate interns, an indirect or collaborative partnership with a university forensic science program may still be beneficial. This type of collaboration ensures that the hands-on skills required for working in a DNA forensic laboratory are incorporated into the university's curriculum so that students are better prepared

Forensic Academic Opportunities

Marshall University offers a creative internship, the Technical Assistance Program, which benefits both its forensic science graduate students and laboratories throughout the DNA community. It sends pre-trained

graduate students to DNA laboratories around the country to perform internal evaluation and validation of DNA technologies. For more information, go to <https://www.marshall.edu/forensics/tap>.

FBI Quality Assurance Standards: Coursework Requirements

At minimum, a DNA analyst must have a bachelor's or postgraduate degree in biology, chemistry, or a forensic science-related area. Additionally,

DNA analysts must have successfully completed coursework in biochemistry, genetics, molecular biology, and statistics/population genetics.

Source: Standard 5.4.1 in Federal Bureau of Investigation, *Quality Assurance Standards for Forensic DNA Testing Laboratories*, Washington, DC: U.S. Department of Justice, Federal Bureau of Investigation, 2020, 17, <https://www.fbi.gov/file-repository/quality-assurance-standards-for-forensic-dna-testing-laboratories.pdf/view>.

for the transition to a laboratory position. Laboratories can use the partnership to encourage universities to support the academic coursework required by the FBI's Quality Assurance Standards for Forensic DNA Testing Laboratories.¹⁹ With the popularity of forensic science educational programs on the rise, it is necessary for students and laboratories to ensure the quality of programs. The Forensic Science Education Programs Accreditation Commission (FEPAC) is an accreditation body for forensic science education programs with standards for both bachelor's and master's degree programs.²⁰ A research thesis or project is one of the standards required for a graduate program. For information on accredited universities see the FEPAC website, <https://fepac-edu.org/faq>.

RECOMMENDATION 29:

Laboratories should have a full understanding of their current hiring practices and adopt a multistep approach to more efficiently screen candidates.

Unfilled vacancies in the laboratory result in lost productivity and an extra burden on other employees asked to do double duty or overtime. Laboratories should review their current hiring practices to identify areas for process improvement. Improving the efficiency of the hiring process will allow laboratories to fill vacancies more quickly and will provide an edge in a highly competitive marketplace. Candidates who are part of a long and tedious hiring process may lose interest or accept other job offers at agencies able to make faster hiring decisions. Periodic communication with candidates is essential, so that qualified individuals know they have not been forgotten.

¹⁹ Federal Bureau of Investigation, *Quality Assurance Standards for Forensic DNA Testing Laboratories*, Washington, DC: U.S. Department of Justice, Federal Bureau of Investigation, 2020, <https://www.fbi.gov/file-repository/quality-assurance-standards-for-forensic-dna-testing-laboratories.pdf/view>.

²⁰ Forensic Science Education Programs Accreditation Commission, "Accreditation Standards," Colorado Springs, CO: American Academy of Forensic Sciences, September 2021, https://fepac-edu.org/sites/default/files/2021%200924%20FEPAC%20Standards_0.pdf.

Advertise the Specifics of Positions

When advertising open positions, laboratories should include detailed descriptions of job duties (including the instrumentation and technology used at the laboratory), qualification requirements (including whether a full background check is

required), salary, benefits, job site location, and promotional opportunities. Starting a job search with an informative foundation can help candidates understand the requirements for the position and set their expectations prior to applying for the job.

Screening candidates helps determine if they would be a good fit for the workplace. To efficiently screen candidates:

- Laboratories should request detailed documentation of previous laboratory experience and scrutinize relevant coursework transcripts to determine if candidates meet the minimum requirements. These documents, along with letters of recommendation or references, should ideally be submitted prior to the initial interview.
- A preliminary phone interview should be conducted to learn more about qualified candidates and further narrow the applicant pool. The interviewers should use a script of questions designed to elicit whether the candidate's core values align with the mission of the laboratory. Interviewers should also inquire about the individual's laboratory experience and knowledge of laboratory techniques.
- Before proceeding past the preliminary interview, laboratories should perform a quick criminal background check to ensure all remaining candidates meet the laboratory's hiring criteria.
- The laboratory should review all reference material provided by candidates selected for in-person interviews before those interviews are conducted. In addition, the laboratory should contact the personal and professional references of each candidate, relying on a list of prepared questions to gain insight about the individual's work ethic, experience, interpersonal skills, character, and credentials. A candidate who can forge good relationships with co-workers and supervisors will bolster efficiency in the laboratory. The technical leader should review the candidates' transcripts to ensure that they have the required coursework for the position.
- An in-person interview is the best way to evaluate a candidate. The laboratory should use this opportunity to assess critical thinking and presentation skills. In addition, or as part of the interview, the laboratory should consider administering a knowledge-based test or assessment of practical laboratory skills. The laboratory should appoint a hiring committee to perform these evaluation tasks.
- The laboratory should determine if a full background check is required for employment. Eliminating unnecessary full background checks can dramatically shorten the hiring process.

A Creative Way To Get To Know a Prospective Employee

Before making an offer to a prospective employee, consider having the candidate shadow an analyst for a day. While the analyst is performing daily tasks, the candidate can gain firsthand knowledge about job expectations. Additionally, the analyst can

assess the candidate's interaction with others in the workplace as well as their level of comfort with the daily job responsibilities. Shadowing may provide one last opportunity to determine, before hiring, if the candidate is a good fit for the job.

RECOMMENDATION 30:

The laboratory should implement a standardized onboarding program to integrate new employees into the laboratory.

Onboarding programs have proved successful in helping new employees adapt and integrate themselves more quickly into an organization. The onboarding experience is often a new employee's first real exposure to the laboratory or organization. A well-designed program can set the standard and establish the foundation for retaining qualified workers.

During onboarding, the new hire should receive an in-person orientation and an employee handbook that contains the organization's mission statement, core values, and code of ethics. The laboratory should also provide other pertinent information about the job, including the policies, procedures, and security expectations of the workplace.

The onboarding program should cover the laboratory's departments and their location, dress code, work schedules, computer access, leave policies, payroll information, and benefits (including pension, retirement plan, and healthcare). Since many employees relocate for employment, the laboratory should also provide information about public transportation, places of interest, and activities near the workplace.

An onboarding program helps create an environment where workers feel valued and are likely to be most productive, contributing to the efficiency of the laboratory.

RECOMMENDATION 31:

Upon hiring, laboratories should initiate a probationary period in order to evaluate the employee's ability to perform the job successfully.

Civil service regulations, unions, and collective bargaining agreements can make termination of poorly performing employees difficult. Many forensic DNA positions are government positions in which these rules

Mentoring New Employees

Laboratories should consider implementing a mentorship program for new employees. New hires may not just be new to the laboratory but also new to the area, often without friends or family nearby. A mentoring program can help new employees adapt to the challenges of both work life and home life.

A mentor should be a role model (preferably someone other than the employee's supervisor or

trainer) with a positive attitude and willingness to help the new employee acclimate to the organization. Mentorship can improve the skills and confidence of new employees by mitigating fear of the unknown and offering the opportunity for the new employee to connect with someone in the laboratory on a personal level.

take effect from the first day of employment, unless a probationary period allowing termination is established upon hiring. A probationary period should, at minimum, last as long as the new employee is in training. Ideally, the time frame would extend beyond the end of training — for example, a probationary period for one year following a new analyst's qualification — so that laboratory personnel are able to ensure that the individual can perform the job independently and successfully.

Laboratories should inform new employees before they are hired about the terms of the probationary period and the requirements they must meet. A probationary period protects the laboratory in case the new employee does not meet minimum work standards for performing casework. Individuals who do not satisfactorily complete the training program would then be released from employment or transferred to another position within the organization.

If considering termination, the laboratory should factor in efficiency, given the resources already expended on hiring and training the individual. Depending on the employee's ability to improve their skill set, it may be more efficient to help them improve rather than to find and train someone new.

Training

Although laboratories spend significant amounts of time and money training new employees, this critical endeavor may sometimes be overlooked when prioritizing the myriad other responsibilities in the laboratory. The recommendations below suggest ways to make new employee training a priority while also making it more efficient.

RECOMMENDATION 32:

To allow maximum flexibility in the allocation of resources, the laboratory should implement a standardized modular training program consisting of only job-relevant components.

“In Training” Status

In some laboratories, employees in a training program have a specific “in training” status. After completing training, the employee is on probation for the first year of performing independent casework.

Only after successful completion of these phases does the employee become a permanent member of the laboratory.

A laboratory should develop a standardized training program that contains only material relevant to performing the specified job functions. Laboratories should review and identify essential training material and components that must be incorporated into the training program, eliminating superfluous material to improve training efficiency.

The training program should be organized in a modular fashion, with an expected time frame provided for the completion of each module and the training overall. A modular approach will afford each laboratory the flexibility necessary to ensure training is completed efficiently based on the laboratory’s particular needs.

Each module should contain an outline, goals, and objectives and conclude with an assessment of how well the trainee has understood the material. The assessment may take the form of written, oral, moot court, or laboratory practical examinations. For example, oral examinations may help evaluate the trainee’s ability to explain complex concepts and ideas to their peers, judges, juries, or other criminal justice stakeholders. The measures of success should be clearly defined for each module assessment to ensure confidence in the fairness of the system. Although it will take time and effort to create the training modules, once in place, they require updating only when new technologies are brought online (see chapter 5) or changes are made to the laboratory’s methods.

The laboratory can also develop a standardized training program by working with a recognized, reputable authority (e.g., NIST, NIJ, the FBI) to create a centralized, standardized curriculum that covers general theory as well as applications in essential topics of DNA analysis. Currently, the federal government offers no standardized DNA training program for state and local laboratories. However, the Forensic Technology Center of Excellence, which is funded by NIJ, offers several specialized courses and webinars in forensic biology.

RECOMMENDATION 33:

Every laboratory should have a designated training coordinator to help prioritize and oversee all training activities.

Test-Out Options

During training, the use of pretests at the start of each module may allow the trainer to concentrate instruction on areas of greatest need for the trainee and reduce time spent on modules for which the individual already has a solid foundation. Depending on a trainee's previous experience, completion of each module may be expedited while still ensuring that the material is covered.

Additionally, the trainee may be able to bypass a module all together, with the approval of the laboratory's technical leader, by demonstrating their knowledge in a particular area. This accelerates the training timeline and reduces the time expended by the trainer, freeing both trainer and trainee to focus on other critical activities.

A lack of resources often makes it difficult for laboratories to give training new staff the high priority it deserves. Recognizing that training is the foundation for a successful and efficient laboratory in which employees work well together, laboratories should prioritize training and designate a training coordinator.

The training coordinator's primary responsibilities should include scheduling trainings and monitoring trainees' progress to ensure that training is completed within the expected time frame. The coordinator should report directly to the laboratory manager or technical leader about the trainees' progress (see chapter 1 on laboratory operations).

The training coordinator should also ensure that training records are maintained in compliance with accreditation requirements and the FBI's quality assurance standards. Additionally, the training coordinator should develop and periodically update the training program, identify qualified trainers from among the analyst staff, assist in training and training assessments, ensure necessary training resources are available, correct training deficiencies, and evaluate the trainers.

Depending on the size of the organization and the number of trainees, the training coordinator may lead a team of trainers or may be the only person who handles training duties. Ideally, if the laboratory has many individuals who need training, the coordinator should have a team of assistants and a designated space to perform the training. Statewide laboratory systems with trainees in different regional facilities should consider centralizing their training in a single location. If that is not possible, the laboratory should consider appointing regional trainers to work closely with the training coordinator in implementing the training program consistently across the facilities.

Analysts, while acting as trainers, will be pulled away from their normal casework. The training coordinator should rotate the analysts assigned to training staff to minimize interruptions in their primary responsibilities of performing casework, allowing them to focus on training during a specified module or time period. A rotation also ensures that trainers do not burn out, which reduces the quality of the training. For the same reasons, it may also be beneficial to use different trainers for each training module or group of modules.

RECOMMENDATION 34:

The laboratory should establish a timeline for the training program in which the training coordinator monitors progress to ensure training remains a priority.

The length of time it takes to train a DNA analyst — currently one to two years in many cases — is a common challenge in the forensic DNA community. To monitor training progress, the training coordinator should set a timeline for completing specific training tasks and the overall training program. Six months to one year is a reasonable goal for training a DNA analyst in techniques and skills ranging from serology to reporting and moot court.

Laboratories should consider the training method that is most efficient for their workplace. Some laboratories may find it most efficient to qualify and authorize a trainee in a set of tasks at the completion of each module or a set of modules. In this scenario, the trainee may not be fully qualified in all techniques and skills but will be able to independently perform specific casework tasks included in the modules that they have successfully completed. This type of modular approach allows a laboratory to use a new hire for actual casework in specific areas much sooner, instead of waiting for the new hire to complete the entire training program and fully qualify as a DNA analyst before beginning any casework.

Other laboratories may find it more efficient for the trainee to complete the entire training program and then qualify and authorize them in all techniques and skills all at once. In this scenario, setting and adhering to a training timeline is the key to ensuring that training stays on track. No matter the approach, the training coordinator should identify the people responsible for training, clearly define and document the tasks expected of trainees throughout each training module, establish the time frame in which these tasks should be completed, and provide frequent feedback to the trainees on their progress.

Training Progress Reports

Providing documented feedback ensures that trainees are aware of their progress as well as any deficiencies that may have arisen throughout the course of training. By engaging in regular discussions with their trainer rather than waiting

until the formal assessment phase of training, trainees can learn immediately if they are on the right track or need to make adjustments to avoid any formal training setbacks.

RECOMMENDATION 35:

The laboratory should incorporate feedback from trainees into training programs.

To ensure successful training, the trainer and trainee should meet after the completion of each module — if not more often — to discuss the trainee’s progress. A documented discussion is a good way to monitor how the training is progressing and helps to solicit feedback about the training program. At minimum, the trainee should be asked to rate how effective, comprehensible, and engaging the program is, as well as to provide any suggestions for improvement. Giving the trainees, who have firsthand knowledge of the program’s strengths and weaknesses, an opportunity to reflect on their experience and express their ideas is critical to improving the program and incorporating new styles of learning.

Constructive feedback may identify problems such as a particular training section that requires more time than anticipated or readings that are outdated. The training coordinator, technical leader, or laboratory manager should consider this feedback when modifying or updating the training program. Reviewing and appropriately incorporating suggestions from feedback helps ensure that the training program is as technically up to date and efficient as possible.

RECOMMENDATION 36:

The laboratory should provide feedback to employees on their performance during training, after training, and throughout their careers.

An annual performance review is often the standard way to provide feedback to employees, but a once-a-year evaluation is not sufficient to help employees make changes if their work is not meeting goals and expectations. Once an employee has completed the training program, a supervisor should provide frequent feedback on a set schedule (e.g., monthly, quarterly). These regularly scheduled assessments allow supervisors to reward good performance and coach employees in areas that need improvement before problems affect workflow. By establishing an ongoing dialogue, regular feedback creates a more efficient workplace, boosts morale, and helps the laboratory retain staff. More generally, frequent communication between supervisors and employees fosters an environment that allows continuous growth throughout employees’ careers.

Regular Feedback

Regular feedback can occur in various ways. Staff and management should communicate frequently with employees, choosing which mode best suits their communication style and needs. For example, feedback could occur in daily group status meetings, one-on-one meetings (weekly, biweekly, monthly, or quarterly), regularly scheduled phone calls, or email.

Topics to discuss include the status of current tasks, availability for performing new tasks, and progress toward meeting goals. In addition, the employee should discuss any risks or hurdles associated with assigned tasks or goals, so that the supervisor can mitigate these whenever possible.

Retention

Most of this chapter has focused on how laboratories can improve efficiency by adopting best practices for hiring and training. This last section examines how to retain qualified and experienced staff in ways that are both cost effective and improve the overall efficiency of the laboratory.

RECOMMENDATION 37:

To reduce attrition and maintain lab efficiencies, the laboratory should develop strategies to promote employee professional and personal growth.

After devoting time and resources to hiring and training a new employee, it is incumbent on the laboratory to do its best to retain that individual. In some laboratories it can take up to a year before a new employee is actually able to begin work after being hired. When the time it takes to train a new employee (ideally six months to one year) is added to the time spent in the hiring process, laboratories require a substantial amount of time to replace each qualified DNA analyst who leaves the laboratory. Reducing staff turnover is key to maintaining the laboratory's overall efficiency. To that end, the laboratory should invest in promoting job satisfaction and enhancing the professional growth of its employees.

Outlined below are several ways that laboratories can help retain current employees, advance their careers, and optimize the efficiency of the workplace.

Provide Career Opportunities for Employees

Most laboratories support promoting and hiring from within before seeking external candidates. Promoting from within has both financial and time-saving benefits. Background investigations and onboarding, for instance, are unnecessary when promoting internal staff. Additionally, creating a career ladder for current employees to advance while remaining at the laboratory can improve staff morale and challenge employees to take the next steps in their careers.

Laboratories should consider having career paths with both professional and managerial tracks. Many laboratories already prefer to promote from within to fill supervisory positions. Employees who are familiar with the organization and how it is managed can more quickly adapt to a supervisory position. Employees who do not have the desire or skills to be a supervisor can still be given the opportunity for professional growth by providing them with additional responsibilities. For example, a lead technician could manage laboratory work or a senior analyst could coordinate the training program.

Provide Training and Mentoring for Leadership Positions

To build a strong leadership team, laboratories should provide training and mentoring opportunities for the next generation of leaders among their current employees. Despite the benefits of promoting scientists to managers, this also creates many first-time supervisors with little to no management experience. Providing leadership development training to these newly promoted employees will have an overall benefit to the laboratory's efficiency.

Laboratories should institute formal mentorship programs for both seasoned and new leaders. Establishing mentor/mentee relationships forges positive role models and promotes communication among peers as well as helping to develop new leaders. Mentoring programs provide a mechanism for passing on historical knowledge about an organization while enabling employees to explore ways to further their careers.

Alternative Ways To Compensate Staff

If a laboratory cannot offer competitive salaries to attract employees, it should consider alternative incentives and compensation to reward and retain valuable employees. For instance, a laboratory could offer to pay off part of an employee's student loans

in return for a required service obligation. To be eligible for such a plan, an employee would have to successfully complete the training or probationary period and then commit to working at the laboratory for a specified period of time.

Laboratory leaders across all levels should continue to develop their own leadership skills. Many universities and organizations offer both online and in-person leadership workshops and courses.

Provide Funding for Professional Development at Work

Laboratories should invest time and funding to provide professional development opportunities for their employees during working hours. Professional development brings new ideas, knowledge, and perspective into the laboratory, which can lead to a more efficient workplace. Allowing staff to participate in these developmental opportunities can also boost morale and demonstrate appreciation for work well done, which can help to retain employees.

With a heavy caseload, it can be difficult for an employee to focus on professional development. Laboratories should set aside both work time and funding to support this cause. For example, laboratories could schedule a day where employees stop casework to participate in preapproved webinars on DNA-related topics.

Although they can be costly, attending conferences benefits both employees and the laboratory by providing networking opportunities and exposure to innovative ideas. Laboratories should designate annual funding for conference registration and travel costs, or explore grant funding if annual funding is limited.

Alternatively, a laboratory could host its own professional development day, inviting other laboratories to discuss operations, formulate working groups for troubleshooting, and prepare for upcoming changes and new technologies. The laboratory could also invite experts on emerging topics in DNA analysis. Finally, the laboratory could explore web-based continuing educational opportunities and courses as a more cost-efficient option.

Establish Compensation and Rewards Programs

Compensation packages that include paid time off, retirement plans, and salary increases tied to accomplishments are essential in a competitive job market. Incentive programs such as merit-based salary increases may help retain employees who are more experienced and might otherwise leave for higher salaries elsewhere.

Additionally, a reward program that distributes either monetary bonuses or extra time off is a way for the laboratory to demonstrate that exceptional work is appreciated.

Government employers may look to corporate strategies for compensating scientists as a means of retaining staff and maintaining efficiency. For instance, given the cost of replacing highly trained staff, it may be more financially prudent to offer a salary increase or bonus to a valued analyst instead of losing the person to a higher-paying laboratory.

Wellness at the Workplace

A laboratory- or agency-appointed wellness committee could provide health services such as blood pressure checks, blood sugar checks, and annual flu shots. The wellness committee may also invite experts to speak about nutrition and healthy

eating habits or strategies to reduce stress. A laboratory book club, a short lunchtime movie, or in-house exercise classes are other options for providing physical activity and stress relief for employees.

Promote Work-Life Balance

Laboratories should also recognize that a healthy balance between work and family life will lengthen employees' careers and reduce employee burnout.²¹ Implementing flexible work schedules, telework options, and paid time off policies are all ways to help employees achieve this balance and ultimately lead to a more efficient laboratory.

Establishing an employee assistance program (EAP) is a way for laboratories to support employees with personal or work-related problems that could affect their job performance, health, and emotional well-being. Counseling offered through an EAP may reduce the stress and other mental health effects associated with the heavy workload and the nature of forensic DNA casework.

Full time employees spend close to 3,500 hours a year at their workplace. Providing health-related services reduces short-term sick leave and increases productivity. Encouraging exercise by offering gym access provides both physical and mental health benefits. This in turn makes for a better and healthier environment in the workplace.

²¹ National Institute of Justice, "Conditions Affecting Forensic Scientists' Workplace Productivity and Occupational Stress," Washington, DC: U.S. Department of Justice, National Institute of Justice, April 2018, <https://nij.ojp.gov/topics/articles/conditions-affecting-forensic-scientists-workplace-productivity-and-occupational>.

Data Analysis, Data Management, and Information Technology



Even the most dedicated staff will be hard-pressed to manage a laboratory's DNA caseload if they are not given the appropriate resources to properly process and analyze data: time, information technology (IT) tools, and software applications. Efficiently processing data may make the difference between reducing a backlog and becoming overwhelmed with the increasing demand for evidence analysis. Producing a report that is clear, explains all results and the limitations of the data, and can be understood by nonscientists allows laboratory staff to devote more time to casework instead of answering questions from the report recipients.

Data produced during DNA testing proceed through several steps before the information can be reported.²² To improve the speed and accuracy of data processing, evidence analysis, and reporting, analysts need sufficient time to concentrate on those tasks that require human expertise. In addition, these processes can become more efficient with state-of-the-art IT tools. Some repetitive laboratory and analytic tasks, for example, can be performed by robotics, batch sample processing, and innovative IT measures. Several of the recommendations in this chapter provide strategies for streamlining and automating data processing.

IT tools and software applications can aid in data analysis and interpretation, mixture deconvolution, and the determination and transfer of multi-locus genotypes for upload to the Combined DNA Index System (CODIS). They can also help laboratories efficiently communicate DNA test results to stakeholders. Though the analyst may have an opportunity to explain the results to some investigators or attorneys, in many instances communication occurs solely through the laboratory report. Because subsequent steps in the investigation and legal actions (e.g., plea agreements, case decisions) are often based on interpretations of the laboratory report by nonscientists, the report must be clear, concise, and informative.

²² Frederick R. Bieber et al., "Evaluation of Forensic DNA Mixture Evidence: Protocol for Evaluation, Interpretation, and Statistical Calculations Using the Combined Probability of Inclusion," *BMC Genetics* 17 (2016): 125, <https://doi.org/10.1186/s12863-016-0429-7>.

Data Analysis and Reporting

RECOMMENDATION 38:

Laboratories should batch the review of data and controls to reduce redundancy in the technical review process.

Establishing a workflow in which a set of controls or a batch of data undergoes technical review only once prevents needless repetition in the review process. Documentation of the technical review can be maintained and distributed to multiple case files or maintained within the batch paperwork. Assigning the batch review of data to a designated staff member enables other analysts to focus on the interpretation and reporting of data.

RECOMMENDATION 39:

Laboratories should explore and validate software tools to facilitate the review of allelic ladders, controls, and samples.

Software tools can be used not only to assign alleles but also to perform quality checks of controls and to evaluate electropherogram data relative to laboratory-defined settings and requirements. If validated for casework, these tools can provide additional information to aid in the review of data, such as identifying peak height ratios that fail to meet expectations and distinguishing single-source from mixed specimens. Using laboratory-defined criteria to execute rule-based quality assessments, software tools can facilitate data review and analysis by automatically flagging various features in the data, such as potential allelic dropout. These flags may, for example, indicate data quality according to a rating system of “pass,” “review,” or “fail.”

RECOMMENDATION 40:

Laboratories should implement software tools or an interpretation strategy to determine the number of contributors in a DNA sample.

The number of contributors in a DNA sample is integral to probabilistic genotyping and is a required user input for some software programs. Determining the number of contributors is a complex assessment that can lengthen the time required for both the initial interpretation of the profile and the technical review process. Software enhancements and specialized programs that account for factors such as allele sharing of multiple contributors, dropout, and stutter artifacts can help assign a number of

contributors to the DNA typing results.²³ If a software program is not used, then an interpretation strategy — a structured approach for determining the number of contributors with allele count and review of the data — should be used. This approach must be reproducible and subject to technical review.

RECOMMENDATION 41:

Laboratories should use probabilistic genotyping software based on a continuous model for the interpretation of DNA typing results and statistical analysis.

Increasingly, forensic DNA laboratories are relying on probabilistic genotyping software,²⁴ which supplants many tedious and time-consuming manual processes (e.g., DNA interpretation, mixture deconvolution, and statistical weight calculations). Probabilistic genotyping software is particularly advantageous with mixed DNA of three or more contributors and trace contributors.

The most advanced probabilistic genotyping programs for analyzing data and deconvoluting mixtures are based on a continuous model. Compared to semi-continuous or discrete models, continuous models use more typing information (e.g., peak heights, stutter percentages, mixture ratios) and typically model more profile qualities (e.g., degradation, inhibition). While probabilistic genotyping in general eliminates time-consuming manual processes and may reduce the potential for error, the continuous model in particular achieves the greatest gains in discrimination potential and overall utility. Developers also continue to enhance these programs' capabilities, ease of use, and processing speed.

Given the investment of resources required for a laboratory to acquire, validate, train, and implement such a procedure, it is prudent to choose the most advanced software application — a continuous probabilistic genotyping system. This system provides the greatest benefit for what is perhaps the most challenging aspect of forensic DNA testing: mixture interpretation.

RECOMMENDATION 42:

Laboratories should invest in strategies and developments that have the potential to improve efficiency in data analysis and probabilistic genotyping workflows.

²³ Scientific Working Group on DNA Analysis Methods, "Interpretation Guidelines for Autosomal STR Typing by Forensic DNA Testing Laboratories," 2017, https://1ecb9588-ea6f-4feb-971a-73265dbf079c.filesusr.com/ugd/4344b0_50e2749756a242528e6285a5bb478f4c.pdf.

²⁴ Michael D. Coble and Jo-Anne Bright, "Probabilistic Genotyping Software: An Overview," *Forensic Science International: Genetics* 38 (2019): 219-224, <https://doi.org/10.1016/j.fsigen.2018.11.009>.

Several strategies can improve efficiency in data analysis and the probabilistic genotyping workflow. These strategies include batching multiple samples for probabilistic genotyping analyses to run sequentially without user intervention, and using software tools to assist with difficult, tedious, or error-prone functions (e.g., generating a record for CODIS import, automating the import and export of files). To further save time and effort for some typing results (e.g., single-source profiles and simple mixtures), the analyst may consider declaring an exclusion without conducting a probabilistic genotyping analysis.

Laboratories should also identify superfluous practices that do not improve output and explore strategies for improvement, such as clarifying ambiguous language that could be subject to correction or debate upon technical review. As one example, labeling artifacts with “nonallelic peak” or a simple strike-through, rather than using specific identifiers such as “spike” or “pull-up,” might circumvent the need for communication between analyst and reviewer and forestall later corrections.

RECOMMENDATION 43:

Laboratories should customize software output, where possible, to include only relevant information for assessment of the data and review.

Data output from probabilistic genotyping software may include useful information, such as case and specimen identifiers, input data from forensic evidence, genotypes of the persons of interest; assumptions (e.g., number of contributors) and hypotheses used in the analysis, deconvolution results, likelihood ratios in relevant population groups for unrelated and related individuals, and any diagnostic output that aids in assessment of the data. To streamline the assessment and review of results, only those outputs that support the analysis and review should be included in the case file. Depending on the laboratory’s policy for records management, any extended output data (i.e., data not included in the software’s report of analysis) may be retained in electronic format.

RECOMMENDATION 44:

Laboratories should continually explore ways to improve the efficiency and accuracy of technical and administrative reviews to aid in timelier issuance of reports.

DNA analysts should adopt the mindset of being their own “first reviewer,” thoroughly scrutinizing the case file before it is presented for technical review. Any back-and-forth communication between the DNA analyst and the technical and administrative reviewers about an issue or modification in the case file can delay the issuance of reports.

To reduce delays in review, laboratories should identify issues (such as spelling, typographical, and transcription errors) that the technical reviewer can correct, rather than leaving them for the reporting analyst to remedy. Moreover, staff should focus on strategies for avoiding repetitive mistakes. By tracking corrections, the laboratory may identify recurring issues that can be remedied through awareness and discussion, avoiding the need for those corrections in the future.

RECOMMENDATION 45:

Communication of preliminary results should be limited to exigent situations to preserve resources and maintain efficiency in normal casework analysis.

While beneficial to customers, providing preliminary results by phone or email and recording the communication in the case notes consume resources. Laboratories should provide preliminary results when necessary but focus primarily on issuing timelier written results through laboratory reports.

RECOMMENDATION 46:

Laboratories should identify and clearly define conditions under which statistical analysis is not required and reporting can be abbreviated.

Laboratory reports are written and subjected to technical and administrative review in accordance with the FBI's Quality Assurance Standards for Forensic DNA Testing Laboratories²⁵ and any applicable local laws. The laboratory should ensure that work-saving strategies indicated under those measures are employed in statistical analysis and reporting.

For example, the FBI standards do not require statistical analysis for exclusionary conclusions, evidentiary typing results that are not compared to a known profile, or evidentiary typing results that are consistent with an individual whose DNA is reasonably expected on an item of evidence (an "assumed contributor"). If a case is adjudicated or otherwise discontinued (e.g., the request for examination is withdrawn prior to DNA testing), the laboratory can issue a simplified report stating that evidence was received but not examined. When no examinations or conclusions are reported, a laboratory may determine that only an administrative review is necessary.

²⁵ Federal Bureau of Investigation, "Quality Assurance Standards for Forensic DNA Testing Laboratories," Washington, DC: U.S. Department of Justice, Federal Bureau of Investigation, 2020, 11, <https://www.fbi.gov/file-repository/quality-assurance-standards-for-forensic-dna-testing-laboratories.pdf/view>.

RECOMMENDATION 47:

Laboratories should streamline communication of results through the laboratory report by using standardized statements and formatting, facilitated by software tools.

With the exception of case-specific information, the report should use standardized statements to document the testing performed, results, conclusions, and disposition of the evidence. Using software tools — e.g., a laboratory information management system (LIMS), macros, templates, or specialized software — to format the report and prompt the writer to insert standard report language is time-efficient and less prone to error, allowing the analyst to focus on the accuracy of the information. Report content that can be semi-automated includes the evidence listing, statement of examinations performed, tables, conclusions from serological and DNA testing, statistical statements, and explanatory endnotes. The use of reporting software tools can also reduce the number of corrections and exchanges between analyst and reviewers and contribute to a more timely completion of technical and administrative reviews.

RECOMMENDATION 48:

Laboratory reports should include supplementary information to aid laypersons in understanding the meaning and context of the information and to document any relevant limitations.

Reports of examination contain critical information that stakeholders need to understand. Ideally, the laboratory report is clear enough on its own to preclude the need for subsequent communications explaining the findings and conclusions. Taking sufficient time to write a clear, detailed summary of the results and conclusions can save time overall by reducing the need for follow-up exchanges. If any communication between the analyst and stakeholders does take place, the laboratory should use those instances to learn how similar statements in future reports could be clarified in advance. Laboratory staff should confer regularly — at least annually — on report wording. When any significant modification to a procedure or policy occurs, the laboratory should craft new standard reporting language that reflects the change, if needed.

Each report should include an explanation of technical terms (e.g., likelihood ratio), qualitative descriptors (e.g., the verbal scale described by the Scientific Working Group on DNA Analysis Methods²⁶), the meaning

²⁶ Scientific Working Group on DNA Analysis Methods, "Recommendations of the SWGDAM Ad Hoc Working Group on Genotyping Results Reported as Likelihood Ratios," 2018, https://1ecb9588-ea6f-4feb-971a-73265dbf079c.filesusr.com/ugd/4344b0_dd5221694d1448588dcd0937738c9e46.pdf.

of presumptive and confirmatory results of serological testing, and any resources (such as the laboratory's webpage) for general information about laboratory testing. Explanations of the limitations of the testing (e.g., inconclusive statements) should also be included.

Information Technology Planning and Resources

RECOMMENDATION 49:

Laboratories should have a documented strategic information technology (IT) plan to support current operations as well as future needs and developments.

The laboratory's strategic IT plan should define the strategy, organization, infrastructure, and investment required to support the laboratory's mission. This plan should, at a minimum, address the following:

- Physical components (e.g., hardware, workstations, instrumentation, robotics) and licenses for all staff as needed.
- Electronic backups and storage, to include anticipation of increased demands over time.
- Network and IT quality control.
- Separation of servers or other components as appropriate (e.g., for handling classified information, robotics).
- User privileges and other aspects of security.
- Internet and intranet needs.
- IT failure and power outages, recovery, troubleshooting, and user support.
- IT resources, including funding for maintenance and dedicated personnel.
- Cost-benefit analysis (including personnel resource needs) and risk assessment.

Forensic DNA testing entails the use of technologies that change over time and may require validation studies to implement into casework. Laboratories should keep current with these developments, but software updates and new installations should be limited to those that enhance the laboratory's capability, efficiency, productivity, security, or quality control.

RECOMMENDATION 50:

Laboratories should staff dedicated in-house IT professionals to decrease the time the DNA analysts spend on troubleshooting connectivity and other IT issues.

The laboratory's IT professionals should have the skills and certifications necessary to support the IT strategic plan; the IT professionals do not conduct casework. Their skills enable the laboratory to remain operational and stay abreast of developments and upgrades. Their responsibilities should include network, hardware, and software management and systems integration (e.g., robotics); information assurance and security to safeguard networks and intellectual property from data loss; and other development, maintenance, and troubleshooting support. IT professionals should be employed on-site and — given the dependence of DNA operations on networks, hardware, and software — should be dedicated to supporting DNA laboratory users.

RECOMMENDATION 51:

Laboratories should have an IT system that provides secure, real-time access to information to facilitate efficiency in case processing.

IT systems such as shared networks provide a steady access point for integrating staff with one another, as well as with data, software, hardware instrumentation, and storage. Using a network to remotely access stored data (including those generated or housed on-site and in a multilaboratory system off-site) streamlines the distribution and exchange of information, and assists with report writing and stakeholder communication.

RECOMMENDATION 52:

Laboratories should have ample computing capacity to efficiently analyze and store complex and large data files.

Processing, memory, and storage requirements can be anticipated for a given software program. Some probabilistic genotyping software programs, for example, have high processing demands and produce large output files. The laboratory should provide sufficient computing capacity — memory and processing speed — for personnel to efficiently use the software. The laboratory also needs enough software licenses to ensure ready availability to users. For some activities, multiple or large computer monitors can facilitate data analysis, data review, and the execution of simultaneous functions. The architecture of the computing and analysis capacity should allow multiple users to have simultaneous access and perform high-demand processing. This capacity and flexibility will become even more critical as laboratories begin to process and store the large files associated with next-generation sequencing and in-house typing and bioinformatics.

Laboratory Information Management Systems

For many laboratories, the increasing volume of evidence submitted for DNA testing, along with the myriad examination techniques and analyses discussed in the Data Analysis and Reporting section above, demand the use of some type of electronic assistance. A software-based laboratory information management system (LIMS) is an essential tool for efficiently managing and optimizing DNA laboratory operations. LIMS software may be commercial off-the-shelf (COTS), customized by the laboratory, or developed in house by laboratory IT staff.

Among its multitude of functions, a LIMS can link personnel, instruments, software, and information within the laboratory; track and document activities such as case intake, chain of custody, and evidence and sample processing; report production, technical, and administrative reviews; and track the location of case files. A LIMS can also serve as a repository for quality control and case documentation; generate audit trails; track maintenance and issue alerts; monitor a consumables inventory and reagent use; provide accounting and budgeting information; manage workflow through case prioritization/triaging, examination planning, and staffing needs; produce metrics that aid in task assignments and workload management; and identify bottlenecks in processing. All of these capabilities help reduce turnaround time and case backlogs.

While a LIMS can identify procedures and processes for optimizing laboratory efficiency, the software system does not function in isolation. The strategic IT plan must include adequate support for the LIMS from the laboratory's IT specialists. IT staff resources provide the backbone for the daily operation of a forensic DNA laboratory.

RECOMMENDATION 53:

Laboratories should use a LIMS to track and manage casework activities and store and retrieve case-related information.

Given the increasing demand for DNA analysis, a customizable LIMS is essential for maximizing the ability of the laboratory to process DNA evidence, manage and optimize its activities, and effectively report examination results to stakeholders in a timely fashion. A LIMS is most effective when used in conjunction with laboratory instrumentation and other hardware and software systems to automate as much of the laboratory workflow as possible. These peripherals

may include barcoding systems,²⁷ external information databases, and macro-enabled workbooks (“smart” Excel workbooks that automate calculations and auto-populate information fields, among other tasks).

Although a LIMS can increase efficiency in any laboratory, the system’s impact will vary depending on the product and the degree to which the laboratory incorporates the various functions, tools, and peripheral systems into its operations. At a minimum, a LIMS should record case submission information and track evidence/samples throughout the analysis life cycle, reducing the administrative burden and allowing analysts to focus on tasks that require critical thinking, such as interpreting results.

RECOMMENDATION 54:

Laboratories should use a LIMS to identify trends and bottlenecks to manage resources, maintain efficiency in sample processing and case administration, and meet performance goals.

Because a LIMS provides transparency, adaptability, and tracking capabilities, it can be used to objectively identify bottlenecks in the laboratory’s workflow. Information retrieved from a LIMS can also be used to evaluate performance goals and assist team members in maximizing their efficiency and productivity.

Laboratory management staff should continually review metrics produced by the LIMS to make informed decisions regarding resource allocations and case prioritization — especially when processing high-priority cases — to efficiently move evidence from intake through issuance of the laboratory report.

By tracking activity milestones, a LIMS can also provide processing times for each laboratory procedure (e.g., evidence examination, extraction, quantification, amplification, capillary electrophoresis, report writing, and technical and administrative reviews). The laboratory can use these data not only to identify bottlenecks but to evaluate the success of mitigation plans developed to address those bottlenecks. If the solution to one issue creates a problem elsewhere in the process, the LIMS data can reveal that as well.

By using a LIMS to track case prioritization, managers can ensure that priority levels are effectively communicated to all applicable staff. The ability to classify a case as expedited in a LIMS should extend beyond assigning a target turnaround time; laboratories should be able to query the status of all open rush cases. All staff working on a rush item should be aware of the case status to aid in bench-level decision-making.

²⁷ Tom Karygiannis et al., *Guidelines for Securing Radio Frequency Identification (RFID) Systems*, Gaithersburg, MD: U.S. Department of Commerce, National Institute of Standards and Technology, Computer Security Division, April 2007, NIST special publication 800-98, <https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-98.pdf>; and Shannan R. Williams et al., *RFID Technology in Forensic Evidence Management: An Assessment of Barriers, Benefits, and Costs*, Gaithersburg, MD: U.S. Department of Commerce, National Institute of Standards and Technology, Technical Working Group on Biological Evidence Preservation, November 2014, NISTIR 8030, <http://dx.doi.org/10.6028/NIST.IR.8030>.

“Other” Cases

In addition to an array of specific case types, laboratories typically also have an “other” case classification to use when no existing case type is a good fit. When classifying cases in a LIMS, this category should be used sparingly; each “other”

classification is potentially a missed opportunity to capture useful data about case types. The laboratory should periodically query its “other” cases and evaluate whether further types should be added to its classification scheme to generate more useful metrics.

RECOMMENDATION 55:

Laboratories should use a LIMS to identify and evaluate case acceptance trends relative to laboratory capacity.

The laboratory should ensure its LIMS stores case submission and agency information in a searchable manner. The laboratory should also use the LIMS to identify the total number of cases accepted per unit time, the total number of case types, the number of items requested per case type, and the turnaround time for individual items and cases as well as case types. This will help laboratories establish their capacity for case acceptance and potentially modify case acceptance policies to reflect that capacity.

RECOMMENDATION 56:

Before selecting a LIMS, a laboratory should consider system requirements; projected needs and costs of customization; and user-acceptance testing, training, and implementation; and then prepare a purchase strategy that includes a budget for future growth, maintenance, and IT support.

To ensure that the capabilities of a LIMS will meet the laboratory’s expectations, a team of designated staff should conduct extensive planning prior to purchase. This team should include the technical leader, quality assurance manager, laboratory manager, analysts, technical staff, and staff experienced with existing IT systems. The following questions should guide laboratory personnel before and during communication with LIMS developers and vendors:

- **What LIMS capabilities does the laboratory need?** These are distinct from the capabilities that the laboratory would want if it had unlimited financial resources. To facilitate defining these requirements and communicating them to the vendor, it can be helpful to generate a detailed process map of laboratory activities and procedures. The map should include components such as networks/servers, barcoding, integration, instrumentation, consumables, chemicals, quality control elements, legacy data, backups, and other present and anticipated future needs.

- **What can the vendor offer?** Laboratory staff should develop a complete understanding of vendor offerings, including COTS features, customization, time frame for delivery, testing, training, support, upgrades, and enhancements.
- **How will the vendor meet the laboratory's requirements and expectations?** The laboratory and vendor staff should meet initially to review the specific requirements for case statistics, case monitoring, and grant surveillance. The vendor should be available for ongoing support when using the product.

Further considerations for purchasing a LIMS can be found in appendix C.

Best Practices for New Technologies



Introducing new technologies — new chemistries, instruments, and software — into a forensic DNA laboratory is a complex and costly undertaking that nonetheless occurs frequently. Validation of new instruments requires, in addition to funding, considerable amounts of time from analysts or other designated personnel. Fraught with technical and operational challenges, the introduction of new technologies may cause considerable changes to procedures — changes which then need to be communicated to both staff and stakeholders. However, the laboratory can employ a number of strategies to promote efficiency throughout this challenging process. This chapter discusses best practices for systematically vetting, procuring, validating, and implementing new technologies in forensic laboratories.

Needs assignments

Laboratories should identify technology needs for both their day-to-day operations and their overarching mission. Needs may arise due to several factors, including technology obsolescence, improvements in the state of the art, or changes to national requirements. Laboratory personnel should remain abreast of advances in the field through professional conference attendance, online research, literature review, networking groups, lectures, courses, and workshops. Keeping current on trends in DNA analysis will enable the laboratory to efficiently adapt to new technologies as they emerge.

Vetting

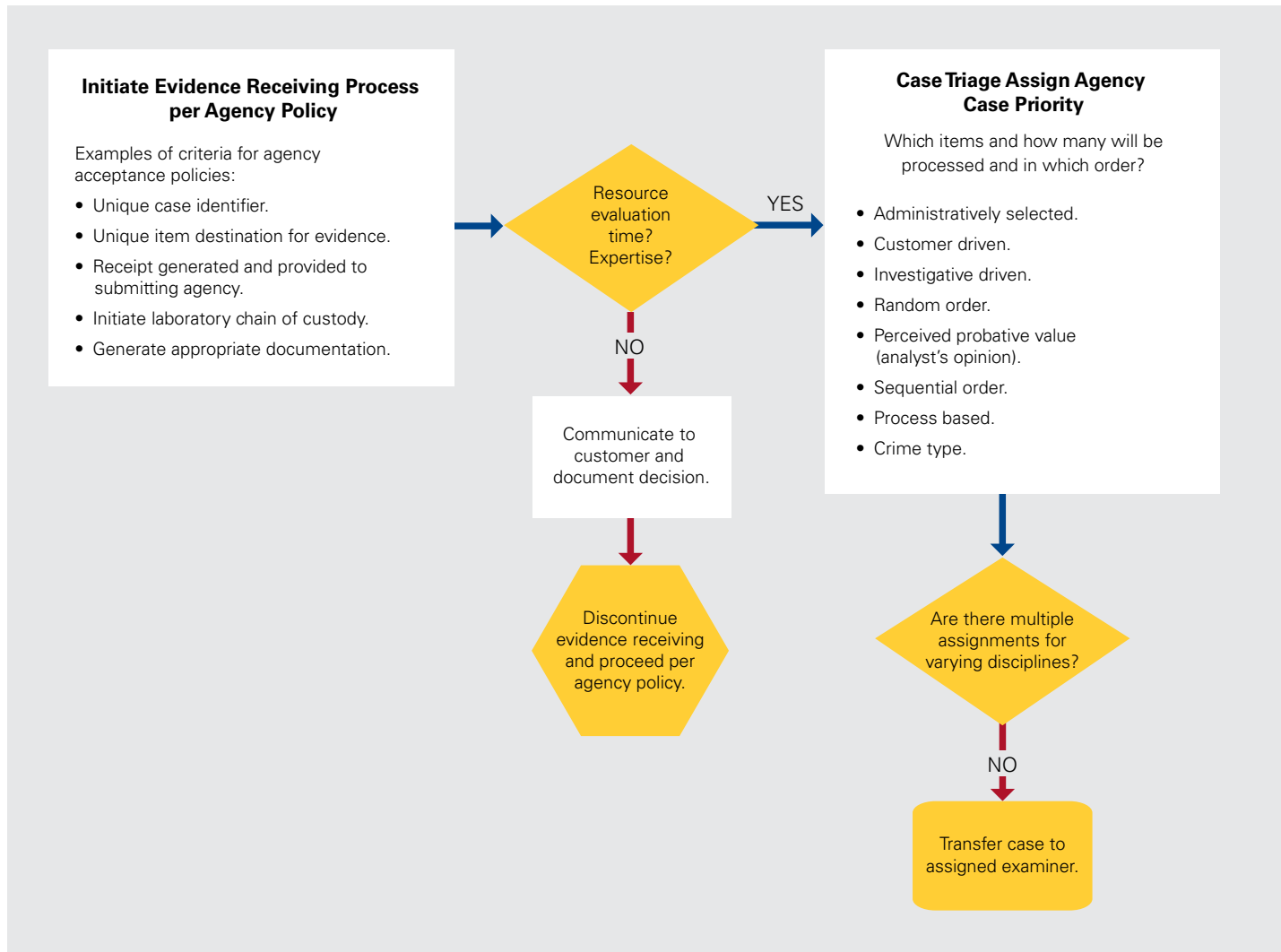
RECOMMENDATION 57:

To choose new technologies wisely and efficiently, laboratories should consider bottlenecks as well as short- and long-term plans.

The constant barrage from marketers claiming that new instrumentation, chemistries, or software packages will greatly benefit forensic laboratories can make it difficult to determine when and how often laboratories should review new technologies. It is therefore paramount that key

laboratory personnel (e.g., managers, supervisors, and technical leaders) understand the current workflow, bottlenecks, and the short- and long-term plans for the laboratory. An informed staff can determine if a particular technology is an actual need (as opposed to a want) and justify the budget necessary for its acquisition. Bottlenecks may be identified

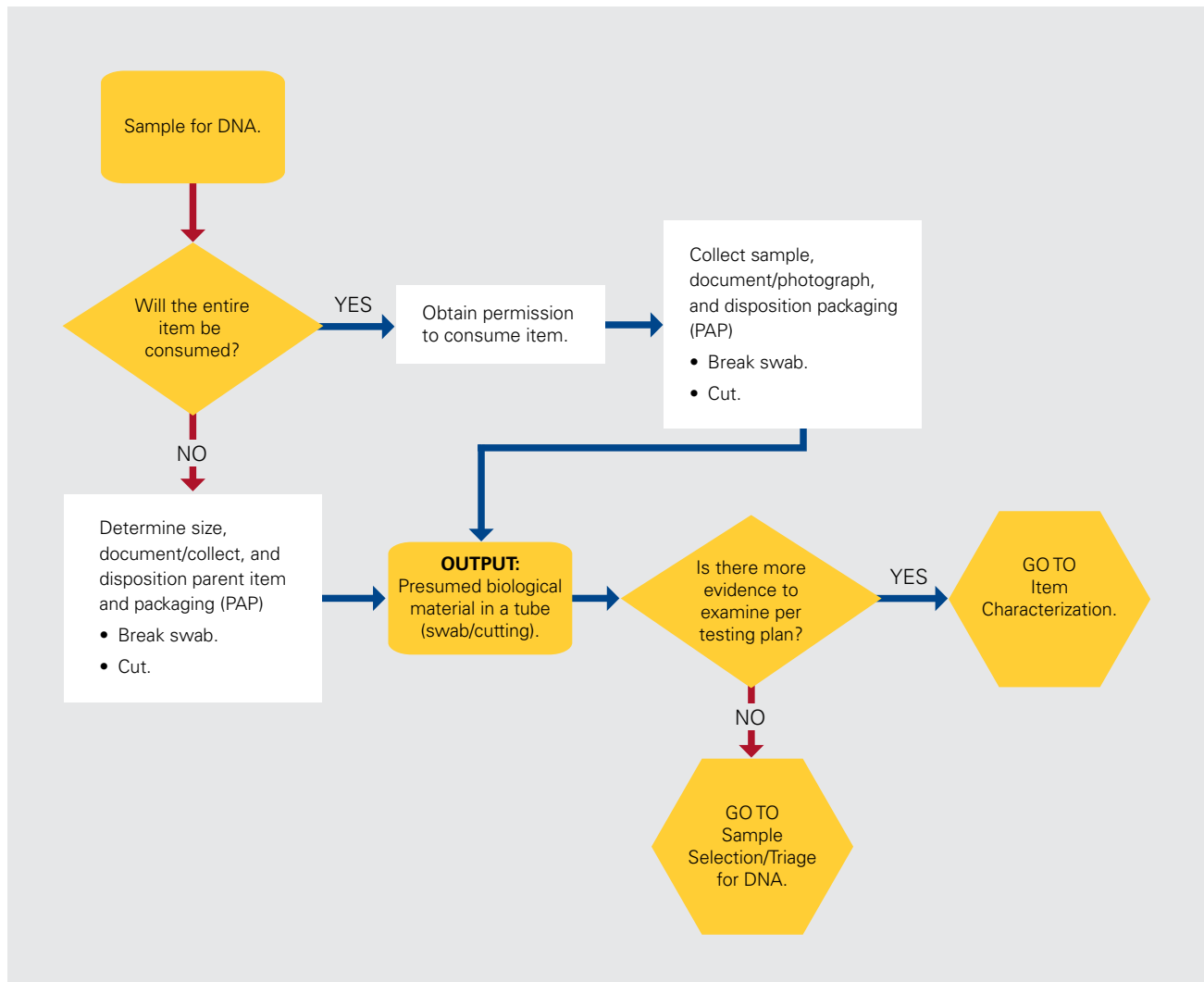
EXHIBIT 2. MAPPING THE INTAKE PROCESS



Note: Mapping the intake process can help identify steps in which a LIMS would be useful and factors affecting workflows that can be organized to promote efficiencies.

using LIMS queries,²⁸ process mapping strategies (see exhibits 2 and 3),²⁹ Lean Six Sigma approaches,³⁰ or other methods.³¹ For example, a LIMS can be implemented to auto-assign internal case identifiers

EXHIBIT 3. MAPPING THE COLLECTION PROCESS



Note: Mapping the collection process can identify areas of efficiency gains. For example, permission for evidence consumption can disrupt the progress of a batch and may therefore be more efficiently obtained preemptively during the triage or evidence submission stages.

²⁸ Gerst A. Gibbon, "A Brief History of LIMS," *Laboratory Automation & Information Management* 32 no. 1 (1996): 1-5, [https://doi.org/10.1016/1381-141X\(95\)00024-K](https://doi.org/10.1016/1381-141X(95)00024-K); and Benoît Leclair and Tom Scholl, "Application of Automation and Information Systems to Forensic Genetic Specimen Processing," *Expert Review of Molecular Diagnostics* 5 no. 2 (2005): 241-250, <https://doi.org/10.1586/14737159.5.2.241>.

²⁹ Paul Savory and John Olson, "Gdisciplines for Using Process Mapping To Aid Improvement Efforts," *Hospital Management Quarterly* 22 no. 3 (2001): 10-16.

³⁰ William Edwards Deming, *Quality, Productivity, and Competitive Position* (Cambridge, MA: Massachusetts Institute of Technology, 1982).

³¹ Scientific packaging Group on DNA Analysis Methods, "Recommendations for the Efficient DNA Processing of Sexual Assault Evidence Kits," 2016, https://1ecb9588-ea6f-4feb-971a-73265dbf079c.filesusr.com/ugd/4344b0_4daf2bb5512b4e2582f895c4a133a0ed.pdf.

and item designations, which may then be transferred electronically for case triage. Triage can follow designated workflows based on urgency (e.g., a rush process) or crime type (e.g., a burglary batch).

Once a laboratory establishes the need for a specific technology to enhance efficiency, it should conduct an in-depth investigation of that product. Product research can include web searches to evaluate the product and any competitor products, a literature review to explore any published use of the technology, and communication with laboratories that have tested or implemented the technology, including RTI International landscape studies. This investigation will save time by ensuring that new research does not duplicate studies already conducted and may also streamline the validation and implementation processes.

If its organizational policies allow, the laboratory should investigate whether a vendor is willing to provide a “loaner” instrument, trial-version software, or complimentary consumables so that the laboratory can evaluate the new technology firsthand before committing to a purchase. When performing these evaluations, the laboratory should intentionally include studies that can be incorporated into a later validation, should procurement proceed.

Costs and Benefits to the Laboratory

RECOMMENDATION 58:

A laboratory should anticipate potential changes in facilities, information technology, safety, and physical and personnel resources to accommodate the new technology.

As part of the initial assessment for a new technology, the laboratory will need to compile the costs associated with implementing it. These expenditures may include necessary enhancements to the facility, IT infrastructure, staffing resources, and other domains of the laboratory related to the new technology. Identifying these costs at the outset can prevent later delays during procurement, installation, validation, and implementation of the technology. It will also be critical to reevaluate these costs as casework volumes grow — the resources, such as computer memory, that may be adequate today to support a new technology may no longer suffice in another two years.

Initial cost assessments should consider:

- **Facilities.** Instruments may require dedicated power and specific temperature controls, among other criteria. Laboratories must make certain that vendors clearly communicate the installation and minimum facility requirements before purchase. If the laboratory

space does not meet the minimum instrument requirements, the facility may have to be expanded or other adjustments made before the technology can be implemented.

- **IT requirements.** The laboratory should determine the IT requirements for the new technology to ensure that all necessary IT infrastructure is either in place or will be acquired before purchase. This minimizes the risk of acquiring technology that is incompatible with the laboratory's IT infrastructure, security, or LIMS. Assessing these requirements is essential, as they will determine if the laboratory needs additional funding for the initial cost as well as outlying years (for example, annual license fee expenditures for software and support).
- **Safety.** The laboratory should determine if any new physical safety procedures need to be implemented for a new instrument or a new chemistry. These might include personal protective equipment needs, chemical fume hood and storage needs, and waste disposal requirements.
- **Equipment and supply considerations.** The laboratory should ensure that all ancillary equipment and supplies needed to successfully operate the new technology are available and adequately funded. In addition, the laboratory should budget for instrument maintenance and support contracts. Such contracts typically cover routine maintenance and unexpected service needs.
- **Training.** The laboratory should ensure it has the financial and staffing resources for training personnel in the new technology; specialized, vendor-provided training could be necessary.
- **Personnel.** The laboratory should ensure it has the required personnel (e.g., technicians and scientists) to conduct the validation and should plan for the reallocation of personnel resources in a way that minimizes disruptions to routine laboratory functions. The laboratory may choose to do a gradual rollout or all-at-once implementation.

Validating and adopting new technologies can be costly and time consuming. To determine if adding a new technology would be beneficial, the laboratory should balance customer needs with resource availability. The laboratory should also consider the cost of outsourcing versus implementing a new technology in house.³² For example, if a laboratory receives only a few requests for mitochondrial DNA (mtDNA) analysis per year, it may be more cost-effective to outsource those samples than to establish an in-house mtDNA program that includes the purchase of mtDNA-specific technologies, kits, and supplies.

³² Project FORESIGHT can help labs determine return on investment. An archived webinar on this topic from the Forensic Technology Center of Excellence is available at <https://forensiccoe.org/webinar/project-foresight-overview/>.

Procurement

RECOMMENDATION 59:

To minimize delays in purchasing new technologies and validations, designated laboratory personnel should have a full understanding of their agency's procurement processes, based on training and consultation with financial personnel.

Much of the procurement process may be mandated by national, state, and local contracts and procedures, putting it beyond the laboratory's control. Even so, the laboratory should consider how the procurement process affects the purchase of new technology and supplies for validation, as well as associated operational costs. Understanding and properly preparing for the procurement process will make it go more efficiently.

While specific requirements will vary between laboratory systems, the laboratory should consider the impact of various purchasing pathways, such as sole-source purchasing and purchases put out for bid. Purchases made with grant funding may allow some types of acquisitions and not others. The laboratory should also bear in mind that in some cases, the initial purchase of new technology has to be integrated with future supplemental purchases in order to build capacity and redundancy. Efficiencies can be gained by bundling the purchase of the technology with associated supplies, maintenance, and training, if permissible. Additionally, some laboratory systems are limited to purchasing instruments or establishing contracts within a particular fiscal year; this timing should be considered when planning the purchase of new technologies and the associated validation.

Validation

Validation is a process by which a procedure is evaluated to determine its efficacy and reliability for forensic casework and database sample analysis. Developmental validation provides the foundation for a new and novel technology. Internal validation demonstrates the functionality of the technology as adopted and applied by another laboratory. In a multilaboratory system (i.e., more than one laboratory in a single agency), site-specific validation is an abbreviated set of studies performed to further demonstrate the technology's functionality at all locations.

Developmental Validation

Developmental validation is the acquisition of test data and determination of the conditions and limitations of a new or novel DNA method for use on forensic samples. This precedes internal validation, which is the accumulation of data testing the new or novel DNA method to

demonstrate that the established methods and procedures perform as expected in the given laboratory.

Developmental validation consists of three discrete phases, each of which must be approached differently to identify opportunities for efficiency:

- **Preliminary experimentation and development.** An experimentation plan with clear objectives should be created before developing the new technology or method. Because this phase of developmental validation is less prescribed than internal validation, timelines for its completion as well as for finalizing the overall validation may require frequent adjustment.
- **Demonstration testing.** After it has been shown that a new technology or method can benefit the forensic laboratory or the community, the requirements of the relevant FBI quality assurance standards must be met and documented.³³
- **Publication.** Forensic journals support the peer-reviewed publication of new and novel technology and methods applied to forensic science. To streamline the process of drafting a peer-reviewed publication, it is useful to leverage summaries, compiled figures and tables, and protocol drafts documented during the earlier phases of developmental validation.

Developmental validations take advantage of the prescribed framework of an internal validation but require tolerance for problem-solving and overcoming obstacles, particularly during the exploratory experimentation phase. As with an internal validation, it is imperative that the laboratory record key decision points and critical elements influencing the course of development and testing.

RECOMMENDATION 60:

Laboratories are encouraged to publish validation studies to aid other forensic DNA laboratories in efficiently designing their own validation studies.

The development of new technology must be scientifically underpinned with supporting peer-reviewed publications. Further, novel uses of previously published technology components should themselves be published in a peer-reviewed scientific journal. Publishing the work will create a scientific foundation for using the new technology in the forensic DNA community. This published work can help streamline future validation studies for other laboratories that adopt the technology.

³³ Federal Bureau of Investigation, "Quality Assurance Standards for Forensic DNA Testing Laboratories," Washington, DC: U.S. Department of Justice, Federal Bureau of Investigation, 2020, <https://www.fbi.gov/file-repository/quality-assurance-standards-for-forensic-dna-testing-laboratories.pdf/view>; and Federal Bureau of Investigation, "Quality Assurance Standards for DNA Databasing Laboratories," Washington, DC: U.S. Department of Justice, Federal Bureau of Investigation, 2020, <https://www.fbi.gov/file-repository/quality-assurance-standards-for-dna-databasing-laboratories.pdf/view>.

Internal Validation

Laboratories should strive to conduct their own internal validations. In addition to being less expensive than outsourced validations, in-house internal validations provide benefits such as:

- Higher likelihood of learning the limitations of the technology.
- Built-in training for personnel.
- Firsthand knowledge that supports future troubleshooting.
- Ability to modify in real time based on observations made during testing.
- Greater familiarity with casework challenges specific to the laboratory.
- Integration into workflows and LIMS.
- Familiarity with the laboratory's quality assurance system.
- Creation of protocols in real time.

However, laboratory facilities with limited staff may benefit from purchasing vendor validation services for automation scripting and other simple evaluations (e.g., thermal cycler performance checks) to accelerate implementation and allow staff to focus on casework.

If outsourcing a validation, the laboratory should:

- Embed a staff member with the vendor during the validation.
- Consult key laboratory personnel, including the technical leader, for experimental design and sample size suggestions.
- Address all required studies, based on standards and guidelines.
- Address security concerns.
- Obtain DNA profiles of vendor personnel.

Planning

RECOMMENDATION 61:

The laboratory should develop a detailed plan to ensure the successful and timely completion of all testing, protocol development, and summarization of the validation work.

The validation plan is the best way of ensuring efficiency throughout the process of validating a new technology. The plan should establish a validation team, consisting of a project lead and other necessary personnel based on the scope of testing. The plan should clearly define the goals and objectives of the validation, and describe the new technology's benefits compared with current technologies. The goals and objectives of validation should address stakeholders' needs. For instance, a new software intended to decrease the amount of time analysts spend

on mixture interpretation may ultimately decrease turnaround times and backlogs. Key stakeholders in this example are the analysts and laboratory administration, but other stakeholders may also include research and development personnel, practitioners and researchers in other laboratory disciplines, medical and law enforcement partners, attorneys, and legislators.

The validation plan should fully define the scope of validation testing. Often, multiple validations become inextricably linked: Validating a new instrument model or updated method may require revalidation of probabilistic genotyping software. In these cases, multiple validation tests may be conducted simultaneously, since the successful implementation of each depends on the others. Validation plans should also describe portions of the work that have already been adequately addressed by another group (for example, published developmental validation).

The validation plan should explain all studies to be conducted; the level of detail describing each study will depend on the study's purpose and must minimally meet relevant standards.³⁴ Some studies may be performed simultaneously for the sake of efficiency, while others are contingent on another and must be done in sequence. To aid in the development of study design and avoid approaches already shown to be unreliable, laboratory personnel should have ready access to research resources such as scientific, peer-reviewed journals and a librarian if possible.

The laboratory should establish a timeline (e.g., project management Gantt charts) for completing each validation test phase and for the testing overall. This timeline should account for the expected availability of all equipment, supplies, and personnel needed to execute the validation. The timeline will also serve to establish goals and expectations for the personnel involved, as well as ongoing accountability throughout the course of the validation.

Testing

Throughout the validation testing process, the laboratory should employ multiple strategies to ensure efficiency in executing the studies, as well as to ensure downstream efficiency in the summarization phase of validation. Above all, thorough documentation is key to successful testing.

³⁴ Relevant standards include Federal Bureau of Investigation, "Quality Assurance Standards for Forensic DNA Testing Laboratories," Washington, DC: U.S. Department of Justice, Federal Bureau of Investigation, 2020, 11, <https://www.fbi.gov/file-repository/quality-assurance-standards-for-forensic-dna-testing-laboratories.pdf/view>; and The Organization for Scientific Area Committees for Forensic Science, "Biological Methods Subcommittee: Standards," <https://www.nist.gov/topics/organization-scientific-area-committees-forensic-science/biological-methods-subcommittee>. Validation plans may additionally include best practice guidelines — see, for example, Scientific Working Group on DNA Analysis Methods, "Validation Guidelines for DNA Analysis Methods," 2016, https://1ecb9588-ea6f-4feb-971a-73265dbf079c.filesusr.com/ugd/4344b0_813b241e8944497e99b9c45b163b76bd.pdf.

RECOMMENDATION 62:

Throughout the course of validation testing, the laboratory should document key decision points and critical elements to efficiently develop training, operational and technical protocols, and summarization documents.

At the launch of an internal validation, the manufacturer-recommended protocol should be used to provide a uniform framework for the validation team members. This protocol should be dynamic and refined as each study progresses.

A preliminary review of data should be conducted to ensure its quality and suitability for the study and overall validation plan. Early identification of problems with the data minimizes the need to repeat portions of the validation. Data should be stored in an intentional and organized manner to ensure maintenance and availability for review, especially for audit memorialization and discovery requests. Formal data analysis should be conducted only at the completion of each study to reduce the time required to complete all testing. An initial summarization of each dataset should also be conducted at the completion of each study to preserve key ideas for the final summary of the work.

The validation team should convene at regular, planned intervals to report on the status of the validation plan, discuss potential impediments and decision points, and develop possible solutions. At every step and key decision point that defines the direction of the testing, the laboratory should record detailed information about critical elements for inclusion in subsequent training modules and operational and technical protocols. These critical elements should include significant lessons learned, important details of function and use, and useful guidance. Recording these elements throughout testing will ensure the preservation and dissemination of valuable information during summarization, protocol refinement, and training.

Summarization

The summarization report should compile the analysis and assessment of the data generated throughout the course of the validation. The laboratory can improve the efficiency of the summarization process by recording the necessary elements throughout the planning and testing phases (such as the summaries produced at the conclusion of each individual study) and then combining them into a final report. The report should include foundational information on the purpose and specific goals of validation, address each of the studies conducted, detail the methods and materials used, describe the results of each study, and provide key concepts, instructions, and conclusions garnered from the work conducted.

Document Management Tools

A document management tool is a shared electronic space available to all personnel who need access. Commercial products are available, but many laboratories develop a version in house. Key elements

of an effective document management tool include secured access, the ability to share access with relevant and appropriate individuals, ample electronic storage, and a defined organizational system.

Traditionally, the laboratory assembles a physical binder of data and supporting documentation for validation. However, the data supporting documentation, analysis files, and summarization reports may best be stored electronically using a document management tool available to relevant personnel and auditors for review.³⁵

Working protocols, or protocols refined throughout the course of validation testing, should be made available for review and approval upon validation summarization. The protocols should encompass operational and technical standard operating procedures, maintenance procedures (physical and data backup and storage), quality assurance and quality control procedures (i.e., verification procedures), and training modules. These protocols may be refined further during training and implementation but should be largely finalized by the time testing and summarization are complete.

Site-Specific Validations

In a multilaboratory system, the primary internal validation of a new technology is conducted at a single site. Once the full internal validation has been completed at this primary site, all other sites that will be using the technology conduct site-specific validations — a more abbreviated version of the internal validation process to confirm the technology's functionality at each additional location.

Each site validation should begin with a plan that clearly defines the scope of experimentation. Typically, the plan includes sensitivity, precision, and contamination studies.³⁶ The plan and studies should be standardized across all sites in the laboratory system.

The testing conducted during site-specific validation should be subject to similar guidelines as the primary internal validation work, including planned and regular status updates, troubleshooting, and preliminary data analysis.

³⁵ Michael Rubacha, Anil K. Rattan, and Stephen C. Hosselet, "A Review of Electronic Laboratory Notebooks Available in the Market Today," *JALA: Journal of the Association for Laboratory Automation* 16 no. 1 (2011): 90-98, <https://doi.org/10.1016%2Fj.jala.2009.01.002>; and Jeffrey M. Perkel, "Coding Your Way Out of a Problem," *Nature Methods* 8 (2011): 541-543, <https://doi.org/10.1038/nmeth.1631>.

³⁶ Federal Bureau of Investigation, "Quality Assurance Standards for Forensic DNA Testing Laboratories," Washington, DC: U.S. Department of Justice, Federal Bureau of Investigation, 2020, 11, <https://www.fbi.gov/file-repository/quality-assurance-standards-for-forensic-dna-testing-laboratories.pdf/view>.

Summarization of all site-specific validations should include the purpose and specific goals of validation, address each of the studies conducted, detail the methods and materials used, describe the results of each study, and provide key concepts, instructions, limitations, and conclusions garnered from the work conducted. Overall, concordance with the primary internal validation should be observed.

The data, supporting documentation, analysis files, and summarization reports are best stored electronically using a document management tool that is available to relevant personnel and auditors for review. The documentation should clearly indicate the specific sites where the studies were conducted.

Implementation

Implementing newly validated technologies into actual forensic use generally involves a weighty focus on training stakeholders, including laboratory personnel. Laboratories would benefit from a dedicated training coordinator who will keep in mind the training needs of all stakeholders.

When several stakeholders are involved in a transition to new technology, the requisite training may comprise multiple pathways, each customized for the particular trainee — both internal and external to the laboratory. This may include webinars or bulletins assembled for law enforcement and attorneys. The training coordinator should be able to delineate each pathway, create timelines and milestones, monitor progress, and ensure the training is conducted as intended.

New technology implementation may additionally include new software or equipment installations and performance checks, quality checks of production reagent lots, preparations for publication of controlled documents and report templates, IT readiness tests (including LIMS), and addressing any facility or safety issues revealed during readiness preparations. Furthermore, multilaboratory systems may include site validations as part of the implementation process, such that each site may initiate use at a different time.

RECOMMENDATION 63:

The laboratory should appoint a team to develop a documented implementation plan to ensure seamless, timely, and efficient training and technology implementation.

The implementation team's goal is to ensure the efficient implementation of a new technology. The team should be composed of validation, training, quality assurance, and IT representatives, as well as the laboratory's DNA technical leader. If possible, the team should include individuals familiar with laboratory operations and who have different levels of experience, such as junior analysts and supervisors. This diverse composition will ensure that all aspects of the new technology are considered.

The implementation team is responsible for developing an implementation plan. The team must ensure that the plan addresses all aspects of quality assurance — including maintenance, troubleshooting, and reagent quality checks — and that the new standard operating procedures are clear, complete, concise, and correct. Training elements of the plan may include scheduled consultations and briefings with key operations personnel, defined key training elements, identification of staff to deliver training, the beneficiaries of the training (i.e., the stakeholder group), timelines and milestones, pilot runs of the new technology, and IT infrastructure assessments and actions to ensure sufficient support is in place.

RECOMMENDATION 64:

The implementation coordinator should guide the development and consistent delivery of a training plan for end users of the newly validated method to ensure both adequate training and timely completion.

Given the focus on training, the implementation coordinator may also be the laboratory's training coordinator. This individual should drive the creation of the implementation plan, including determining which staff will be trained, who will perform the training, when the training events will occur, and what the training will entail.

The purpose of training in a new laboratory technology is for the trainees to develop and then demonstrate competency in the technology and related methods through newly acquired technical knowledge, skills, and abilities. The key elements of a training plan typically include training events, training materials (i.e., required reading), laboratory exercises, and competency testing. The training events may be formal coursework from external agencies, internally developed courses, webinars, individual lectures, or demonstrations.

For complex technologies (e.g., next generation sequencing), it may be most effective for the laboratory to hold progressive training sessions over an extended period of time. For example, new concepts could be introduced while the validation is still in progress, followed by the core training for qualification, followed by continuing education to actively review key topics.

A training plan typically includes, as required reading for trainees, peer-reviewed literature on the specific technology as it is applied in a forensic setting. Further training material could include non-peer-reviewed publications (such as those from the Scientific Working Group on DNA Analysis Methods), manufacturer manuals, excerpts from textbooks, as well as internal and site-specific validation summarization reports. Laboratory exercises can be designed to familiarize the trainee with the new technology, including its nuances and limitations. Depending on the technology, this may include “wet lab” and computer analysis work.

Finally, competency testing is necessary to demonstrate that the trainee is prepared to perform the new methodology on forensic samples. Such testing may be a written or oral examination, a laboratory practical, a moot court, or any combination of these. In addition to developing a training plan, the training coordinator should oversee the process of developing training and testing materials (e.g., mock cases, datasets, and tests), scheduling and conducting competency examinations, and reviewing and grading examination results. The laboratory should monitor progress and feedback in real time as training begins for a new technology. Monitoring – which can include regular one-on-one or group discussions with trainees and the trainer, or periodic reviews of training progress and documentation – promotes common practices and key understanding and identifies areas that need refinement. Refinement may occur to both the newly developed procedure and the training plan content or delivery.

Effectiveness Review

After implementing a new technology, the laboratory should conduct an effectiveness review. The optimal time for such a review is generally within the first year following implementation. The review should reassess the technology's robustness and evaluate how successfully it has been applied in casework or databasing.

An effectiveness review is an introspective activity conducted to identify gaps, minimize deviations from the set procedures, and establish a way forward to reduce the opportunities for nonconformances to occur. It will also serve to identify workflow and facilities issues that may negatively impact the effectiveness and efficiency of the process.

RECOMMENDATION 65:

After implementing a new technology, the laboratory should evaluate protocols to identify new efficiencies within the workflow.

Once a new procedure is brought online and applied to case samples, it frequently becomes apparent that some aspects of the validation need to be revisited or expanded. This work often falls into the category of material modification, defined as the documented alteration of an existing analytical procedure that may have a consequential effect on analytical results.

Even though material modifications could require more work (such as altering protocols or standardized forms and report templates), they are worthwhile because they help ensure that the new procedures complement one another and work well for the laboratory staff to promote workflow efficiencies. Bringing these modifications online may provide a good opportunity for refresher training on the process, instrument, or software being modified.

Adopting more complex technologies can present challenges for mastering the new knowledge required, such as probabilistic genotyping modeling mathematics. In such cases, analysts may benefit from revisiting more complex topics to reinforce their depth of understanding and refine their ability to articulate the new technology to nonlaboratory stakeholders. Close attention should be paid to analysts' adherence to procedures and protocols (e.g., through the technical review process). This helps ensure that analysts fully understand the new software or instrumentation, and that the protocol rationale has been accepted and integrated.

RECOMMENDATION 66:

The laboratory should implement a plan for DNA analysts to refresh and reinforce theoretical concepts, maintain competence, and minimize nonconforming work.

To streamline processes in order to decrease backlogs, analysts may not have adequate time to reflect on the underlying concepts of the technologies they use. Routinely refreshing and reinforcing the theoretical concepts that underpin common laboratory protocols and newly implemented technologies will improve analysts' ability to troubleshoot technological issues and enhance their proficiency in providing court testimony. Continual review of theoretical concepts is a time investment, but it ultimately produces efficiency gains by decreasing the time analysts spend troubleshooting and minimizing the occurrence of nonconforming work.

RECOMMENDATION 67:

When new and unexpected complications arise post-implementation, the laboratory should be prepared to investigate and resolve them.

Despite the best planning on the part of the laboratory during the vetting, procurement, and validation phases, new and unexpected complications or bottlenecks may arise any time new technologies are introduced. Some examples of issues that may emerge after the validation phase include:

- Environmental conditions and heat load: Humidity may influence the performance of an instrument. Increasing the number of instruments producing heat may require venting or additional temperature regulation, including alterations to the building's heating, ventilating, and air conditioning system.
- Electrical load: Existing electrical circuit breakers may not be sufficient to accommodate the load from the additional instrumentation.

- Workflow: Processes may require adjustments to enhance efficiencies (e.g., revisiting process mapping).
- Refrigeration: Refrigerated storage capacity may be inadequate.
- Hazardous waste: Contracts may need to be altered to accommodate increased waste or changes in regulations.

Depending on the particular obstacle created by a new technology, the resolution may involve collaborating with facilities and maintenance personnel, or it may simply require workflow modifications involving equipment placement, which can be dealt with at the lowest level.

Glossary



backlog: The number of cases in which a final report has not been delivered to a customer within a time frame determined by a laboratory's capacity.

batching: Also known as batch processing, a technique in which a set of samples or cases are processed together by one or more analysts.

case acceptance policy: A policy establishing the standard requirements for the routine submission of case requests to the laboratory for analysis.

Combined DNA Index System (CODIS): A generic term used to describe the FBI's program of support for criminal justice DNA databases as well as the software used to run these databases. The term may also be used to refer to the collection of databases in which DNA profiles are uploaded.

databasing: A practice in which a portion of the laboratory is dedicated to analyzing and uploading known reference samples into the DNA database (e.g., CODIS) rather than handling evidentiary samples.

developmental validation: The initial acquisition of test data and determination of the conditions and limitations for using a novel DNA methodology on forensic samples.

direct to DNA approach: A laboratory process that allows for quick DNA extraction followed by quantification and amplification without the need for re-extraction.

evidence screening: The process of determining the likely biological origin of a body fluid and/or the process of taking inventory, examining, and preserving evidence in preparation for possible DNA analysis.

evidence submission policy: A policy establishing the requirements for submitting evidence for specific case types (e.g., only the sexual assault kit may be submitted for the first round of testing in sexual assault cases, only one item of evidence may be submitted for property crime cases).

internal validation: The accumulation of laboratory test data to demonstrate whether established methods and procedures perform as expected in the laboratory.

laboratory information management system (LIMS): A software-based system for managing and tracking DNA laboratory operations and analysis metrics, including case requests and assignments, case triage, backlogs, and reports out.

Lean Six Sigma: A business methodology that uses team effort to improve performance by systematically reducing waste and reducing variation in processing.

massively parallel sequencing: A high-throughput DNA sequencing technique.

mitochondrial DNA (mtDNA): The maternally inherited DNA located in mitochondria.

onboarding: The process for welcoming and orienting newly hired employees to the workplace.

probabilistic genotyping: The use of biological modeling, statistical theory, computer algorithms, and probability distributions to calculate likelihood ratios and infer genotypes of a DNA profile.

process efficiency: The amount of effort required to achieve an outcome.

rapid DNA: A fully automated, hands-free process for generating a DNA profile.

sexual assault kit (SAK): A package (e.g., envelope, box) containing items for collecting and preserving materials of potential evidentiary value from the bodies of persons reporting sexual assault (e.g., victims).

serological DNA analysis/serological testing: See **evidence screening**.

site-specific validation: See **internal validation**.

single nucleotide polymorphisms (SNPs): Variations of a single base pair in a DNA sequence.

short tandem repeats (STRs): Regions of the human genome that vary in length between people based on a repeated DNA sequence.

submission request: A single request for the analysis of evidence by the DNA laboratory (i.e., case request).

technical leader: The person who oversees the technical operations of the DNA laboratory and who is authorized to stop or suspend operations.

touch DNA: DNA contained in shed skin cells that transfer to surfaces that humans touch,³⁷ a DNA sample of unknown biological origin that results from physical contact with an item of evidence (e.g., touching, grabbing).

validation: The process of evaluating a procedure to determine its efficacy and reliability for forensic casework and database sample analysis. See also **internal validation** and **developmental validation**.

Y-screening: A laboratory process that allows for a quick DNA extraction followed by quantification of a forensic sample to determine the presence or absence of the Y chromosome, i.e., male DNA.

Y-STR: A short tandem repeat (STR) on the Y chromosome.

³⁷ Technical Working Group on Biological Evidence Preservation, *The Biological Evidence Preservation Handbook: Best Practices for Evidence Handlers*, Washington, DC: U.S. Department of Commerce, National Institute of Standards and Technology, 2013, 60, NISTIR 7928, <http://dx.doi.org/10.6028/NIST.IR.7928>.

Appendix A: Example of an Evidence Submission Policy



The following example of an evidence submission policy is intended as a guide for laboratories as they establish evidence submission policies tailored to their own needs.

- 1.1** The evidence should have a legitimate associated service request that complies with the laboratory's policies and services.
 - 1.1.1** If the laboratory does not have the capability to perform the requested analysis, it should not accept the request (evidence). If possible, the laboratory may assist the customer in locating an appropriate agency or organization that can provide the requested service.
 - 1.1.2** Evidence should not be accepted for the purpose of long-term storage or if the laboratory cannot meet the needs of the customer.
 - 1.1.3** General requirements for accepted cases:
 - 1.1.3.1** All requests for DNA analysis should be accompanied by an officer statement and/or police report that includes detailed information about the evidence collected (e.g., location recovered from, who item belonged to). This information is critical for determining what questions need to be answered for a case and if the evidence available can help provide the answers. Additionally, the information is necessary for ensuring that the DNA profiles obtained are eligible for CODIS database entry.
 - 1.1.3.2** DNA evidence samples submitted for the purpose of comparison must be accompanied by the appropriate reference samples.
 - 1.1.3.2.1** In most cases, comparison samples should not be accepted unless both the questioned and reference samples are provided. However, this does not apply to samples submitted for comparison to the CODIS database. For instance, DNA cases with no suspect identified may be submitted with the evidence samples and victim reference sample. Otherwise, all DNA requests must be submitted with known reference samples, to include victims; suspects, if identified; and exclusionary samples as necessary (e.g., consensual sexual partner, property owner).

1.1.3.3 The evidence items submitted should be prioritized, and their number should adhere to the written evidence submission policy.

1.1.3.3.1 Limit items accepted for property crime cases. Items selected should be limited to cigarette butts, bloodstains, drinking or eating surfaces, clothing or hats believed to have had prolonged contact with the wearer, or other items that are believed to have biological fluid (blood, saliva, semen) from the alleged perpetrator.

1.1.4 Examples of cases typically not accepted:

1.1.4.1 Sexual assault evidence collection kits outside the generally accepted collection time window of five days (for living victims) unless exigent circumstances exist or unless mandated otherwise.³⁸

1.1.4.2 Brief-contact touch DNA.

1.1.4.2.1 Touch DNA analysis should be performed only on evidence that would likely contain DNA resulting from the transfer of epithelial cells from the skin to an object due to extended contact.

1.1.4.3 Touch DNA when the item is known to have been handled without gloves during or after collection.

1.1.4.4 DNA analysis on controlled substance evidence.

1.1.4.5 Felon in possession of a firearm.

1.1.4.6 Possession cases including but not limited to:

1.1.4.6.1 DNA analysis on controlled substance evidence for the purpose of drug-related charges (i.e., possession).

1.1.4.6.2 Criminal possession of a firearm.

1.1.4.7 Reanalysis of DNA testing conducted by another laboratory.

³⁸ National Institute of Justice, *National Best Practices for Sexual Assault Kits: A Multidisciplinary Approach*, Washington, DC: U.S. Department of Justice, National Institute of Justice, 2017, <https://www.ojp.gov/pdffiles1/nij/250384.pdf>.

Appendix B: Evidence Submission Policies: City, County, and State Examples



The table below represents a broad overview of examples of forensic DNA laboratory submission policies. These are only examples and are intended to provide guidance for laboratories to establish evidence submission policies tailored to their own needs.

Crime Laboratory	Submission Request Mechanism	Physical Submission of Items	Submission Practice/Policy*
City Laboratory Counties: 2 Submitting Agencies: 1 Biology Section Scientists: 36	Web-based portal Portal contains required fields for information specific to CODIS eligibility	Laboratory evidence technicians make daily trips to the property room to pick up accepted evidence	<i>Burglaries</i> — maximum of two items <i>Sexual Assaults</i> — kit is automatically accepted; maximum of five items if no kit was collected <i>Homicide</i> — maximum of 10 items <i>Crimes Against People</i> — maximum of five items
County Laboratory Counties: 1 Submitting Agencies: 44 Biology Section Scientists: 28	Pre-log in laboratory information management system (LIMS) Biology-specific questions with required fields	In-person or via evidence control personnel	<i>Property Crimes</i> — maximum of two samples tested Reference samples must be submitted before case is accepted

Crime Laboratory	Submission Request Mechanism	Physical Submission of Items	Submission Practice/Policy*
<p>State Laboratory</p> <p>Counties: 102</p> <p>Submitting Agencies: 1,200</p> <p>Biology Section Scientists: 63</p>	<p>LIMS pre-log</p>	<p>In-person or via common carrier</p>	<p>Tier 1 Submissions (without laboratory consultation)</p> <p><i>Homicides</i> — maximum of five items</p> <p><i>Sexual Crimes</i> — sexual assault kit (or item if kit is not the most probative evidence); if no kit, maximum of three items</p> <p><i>Other Crimes Against Persons</i> — maximum of three items</p> <p><i>Property Crimes</i> — maximum of two items</p> <p>Appropriate reference samples requested for all the above</p> <p>If probative information is obtained from Tier 1 analysis, no further submissions accepted without approval of laboratory director or other designated laboratory manager</p> <p>Tier 2 Submissions (require consultation with assigned case analyst or supervisor)</p> <p><i>Homicides</i> — maximum of five items</p> <p><i>Sexual Crimes</i> — maximum of two items</p> <p><i>Other Crimes Against Persons</i> — maximum of two items</p> <p><i>Property Crimes</i> — maximum of two items</p> <p>Additional Submissions</p> <p>If no probative information gained from analysis of Tier 1 or Tier 2 submissions, conference is necessary before any further submissions are considered</p> <p>Conference must include case investigator, assigned laboratory analyst, and an appropriate laboratory manager</p> <p>Exceptions</p> <p>Exceptions require approval of laboratory director or other designated laboratory manager</p>

Crime Laboratory	Submission Request Mechanism	Physical Submission of Items	Submission Practice/Policy*
<p>State Laboratory</p> <p>Counties: 62</p> <p>Submitting Agencies: 432</p> <p>Biology Section Scientists: 52</p>	<p>LIMS pre-log</p> <p>Biology-specific questions and item-type attributes are required fields</p>	<p>In-person or via common carrier</p>	<p><i>Homicides</i> — maximum of 10 items</p> <p><i>Sexual Assaults</i> — sexual assault kit; maximum of four items if no kit collected</p> <p><i>Other Crimes Against Persons</i> — maximum of five items</p> <p><i>Property Crimes</i> — maximum of three items</p> <p><i>Criminal Possession of Weapons</i> — maximum of three swabs of three to four areas on gun</p> <p><i>Criminal Possession of Controlled Substance</i> — maximum of two items of packaging or items with blood/saliva</p> <p><i>Misdemeanors</i> — maximum of two items with suspected biological fluid</p> <p><i>Touch DNA</i> — one swab of point of forced entry (door jambs/window sills), one swab of steering wheel (stolen vehicles)</p> <p><i>Cold Cases</i> — by approved formal application; limited to homicide and sexual assault; maximum of 10 items, or retest of existing DNA extracts using new technology</p> <p>Appropriate reference samples must be submitted along with evidence items</p> <p>Additional Testing Requests</p> <p>If relevant forensic questions are unanswered from first submission of evidence, agency can request additional testing via approved application (adhering to limits outlined above); supervisors can consult with agency and further limit second submissions</p> <p>Submissions Not Accepted/Testing Not Performed</p> <p>Touch DNA evidence items routinely handled by victim/complainant with minimal contact by perpetrator</p> <p>Touch DNA evidence known to have been handled without gloves during/after collection</p> <p>Retesting on items previously examined by another in-state crime laboratory</p> <p>BB guns, air soft guns, paint ball guns, and other “guns” that do not fall into the definition of a firearm per state penal law</p>

Crime Laboratory	Submission Request Mechanism	Physical Submission of Items	Submission Practice/Policy*
<p>State Laboratory</p> <p>Counties: 77</p> <p>Submitting Agencies: 665</p> <p>Biology Section Scientists: 20</p>	<p>Lab-wide submission form for all disciplines that includes biology-specific questions</p> <p>Form must be included with every submission</p>	<p>In person</p> <p>Biological evidence will not be accepted by U.S. mail or any other common courier under any circumstances, except sexual assault kits, which may be submitted via common courier to meet state statutory submission requirements</p>	<p>All DNA analysis requests must be accompanied by an officer statement or police report that contains information to answer CODIS eligibility questions</p> <p>Appropriate DNA reference samples must be submitted along with evidence items, as needed, with the exception of sexual assault kits (legislatively mandated submission)</p> <p>All biology cases, except sexual-assault-kit-only cases, must be triaged by a duty biologist who approves submission request/item submitted and makes any additional requests of the submitting agency, as necessary; this process may occur via phone prior to submission, or in person at the laboratory at the time of submission</p> <p><i>Property Crimes</i> — limited to three items; limited to cigarette butts, bloodstains, or other items believed to have biological fluid from the alleged perpetrator — may accept clothing or hats if believed to have had prolonged contact with the perpetrator</p> <p><i>Touch DNA</i> — extended contact/transfer (no brief contact swabs)</p> <p><i>Motor Vehicles</i> — only in serious injury or fatality and limited to interior bloodstains when the driver has fled the scene</p> <p><i>Cold Cases</i> — by consultation/approval</p> <p><i>Criminal Paternity</i> — must have known buccal swabs from mother, child, and alleged father; other types of knowns (e.g., tissue sample, uterine contents) not accepted without preapproval</p> <p>Submissions Not Accepted/Testing Not Performed</p> <p>No-suspect DNA cases with CODIS ineligible evidence</p> <p>DNA analysis for purpose of crime scene reconstruction</p> <p>Preapproval Required</p> <p>Controlled substance evidence</p> <p>Criminal possession of firearm (felon)</p> <p>Touch DNA analysis on items known to have been handled without gloves during or after collection</p> <p>Contact DNA analysis on airbags</p> <p>Reanalysis of bio/DNA testing conducted by another laboratory</p>

Crime Laboratory	Submission Request Mechanism	Physical Submission of Items	Submission Practice/Policy*
<p>State Laboratory</p> <p>Counties: 254</p> <p>Submitting Agencies: 1,913</p> <p>Biology Section Scientists: 167</p>	<p>Lab-wide submission form for all disciplines</p> <p>Form must be included with every submission</p>	<p>In person, via drop box (after hours), or via common carrier</p>	<p>No DNA testing for paternity, seized drugs/paraphernalia, or possession of firearms cases; items can be submitted for touch DNA for sexual assault, homicide, and crimes against persons offenses with prior approval from lab</p> <p><i>Burglary/Property Crime</i> — maximum of two items; cannot be touch DNA items</p> <p><i>Sexual Assault</i> — initial submission limited to sexual assault kit, one underwear, and one condom; second submission is maximum of five items and can include bedding</p> <p><i>Homicide</i> — initial submission maximum of 10 items that are most informative (suggest customer consult with laboratory prior to submitting); second submission is limited to another 10 items</p> <p><i>Crimes Against Persons (assault, robbery)</i> — maximum of five items</p>
<p>State Laboratory</p> <p>Counties: 95</p> <p>Submitting Agencies: 340</p> <p>Biology Section Scientists: 65</p>	<p>Lab-wide submission form for all disciplines</p>	<p>Via courier (multiple cases and disciplines on one trip a week) or via single submission by assigned detective, investigator, or forensic technician</p>	<p>Preapproval only required for high-profile submissions or submission with large numbers of items for DNA analysis</p> <p>Other cases are approved at time of submission (phone call to section supervisor may be made by evidence intake personnel)</p> <p>Submission requirements are based on case type, case scenario, number of victims, and assailants</p> <p><i>Trace DNA</i> — maximum of two items</p> <p><i>Non-Sex Offense Misdemeanors</i> — written request required for testing</p>

* These practices and policies are not meant to be all-encompassing but rather to provide current examples and guidance on the development of a policy. Laboratories may choose to use parts of each of these examples to develop the best submission guidelines for their system based on laboratory capacity, testing capabilities, and legislative requirements.

Appendix C: Additional Questions To Consider Before Purchasing a Laboratory Information Management System



Answering these questions before selecting a laboratory information management system (LIMS) will allow laboratory managers to estimate and secure the necessary funding as well as ensure that the system will meet all foundational requirements.

- Have the laboratory's requirements been defined and verified?
- Can the laboratory provide input into the acquisition process?
- Are demos available?
- How many users have implemented the current version of the software?
- Have users fully implemented all functionality or only a subset?
- How is support provided, and what is the response time? How are help tickets prioritized?
- Are user groups available for this software/version to obtain advice from other users?
- Has the laboratory appointed a pilot group of laboratory users that represents all user types and can test all aspects of the system?
 - Have submitters been included in the pilot group when testing electronic submission functions?
- Has the laboratory appointed a system owner who is responsible for ensuring additions/customizations to the LIMS are consistent and documented?
- Are there customizations available that will tailor the system to the laboratory's present and future needs?
- How will laboratory data be migrated to the new system?
 - Can imported data be searched and queried?
- Will the laboratory need to archive its old system or keep it available to access legacy data?
 - What are the costs of maintaining two systems versus forging a method to incorporate all data into the new system?

- How will this new system integrate with current networks and instrumentation?
- What training is offered/available to help users adapt to the new system?
- Does the laboratory have a documented workflow from which a LIMS interface can be created?
 - Does this workflow describe the data that will need to be put into the system?
 - Does the workflow describe the data that will need to be reported out?
- Does the laboratory have personnel designated to manage the system?
 - Does the laboratory have dedicated IT support?
 - Does the laboratory have the resources to create a LIMS administrator role?
- What backup and security settings are available to protect and recover data in case of a software problem or hacking incident?
- Can the LIMS be configured to provide the metrics required by the laboratory?
- Can the system accommodate upgrades to incorporate future technological advancements, such as cloud/networking advancements, or will it become obsolete in a relatively short amount of time?
- If purchased, how long will it take from initial discussions to full implementation of the system?
- Can users contact other customers to ask for a description of their purchase experience?

For laboratory managers who already have a LIMS:

- Is the laboratory using the LIMS to its full potential?
- Has an individual been designated to continually check for manufacturer updates/upgrades? How are updates communicated and provided to the customer?
- Can the laboratory maintain the LIMS as new case types are added and new analyses are brought online?

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