

A Simplified Guide To Forensic Document Examination

Introduction

An abundance of crucial information can be gleaned from documents related to a criminal or civil case. The suicide note found next to the deceased—was it actually written by a killer trying to cover up his crime? The bank robber’s hold-up note—does it contain invisible impressions that indicate the address of the hideout? The will of a wealthy person—was it altered so a relative could receive a windfall?

The discipline of forensic document examination, often referred to as “questioned documents,” is frequently associated with white-collar crimes such as check fraud; however, in practice, this area of forensic science can be used in a wide array of cases from medical malpractice to art forgeries to homicides.

Armed with sophisticated technology, forensic document examiners can peer into the visible and invisible marks on a document to extract an abundance of details that may verify authenticity or provide additional information crucial to the investigation.

The digital age has made the work of forensic document examiners even more important. With the availability of powerful software programs such as Adobe® Photoshop®, Acrobat® and others, it has become significantly easier for criminals to create and manipulate all manner of fraudulent documents from contracts to currency.

Principles of Forensic Document Examination

Forensic document examiners often deal with questions of document authenticity. To determine whether a document is genuine, an examiner may attempt to confirm who created the document, determine the timeframe in which it was created, identify the materials used in its preparation or uncover modifications to the original text.

Documents can be examined for evidence of alterations, obliterations, erasures and page substitutions. Or the examiner can study the methods, materials or machines that created the document, providing key information that can identify or narrow the possible sources of the document. The ink, paper, writing tools, ribbons, stamps and seals used in production of the document may all reveal important clues. The examiner may even discover valuable evidence in a document’s invisible impressions.

A key element of document examination focuses on handwriting. Forensic examination and comparison of handwriting, which includes hand printing and signatures, is based on three main principles: (1) Given a sufficient amount of handwriting, no two skilled writers exhibit identical handwriting features; (2) every person has a range of natural variation to his or her writing; (3) no writer can exceed his or her skill level (i.e., it would not be possible for a marginally literate person who has only learned to produce very basic hand-printed letters to execute perfectly formed, highly skilled cursive writing).

Computer databases maintained by the U.S. Secret Service, German Federal Police and Federal Bureau of Investigation contain handwriting samples from hundreds of thousands of writers. Comparisons of these databases have not identified two individuals who have the exact same combination of handwriting characteristics, adding to the authenticity of handwriting as a solid form of evidence.

Why and when is forensic document examination used?

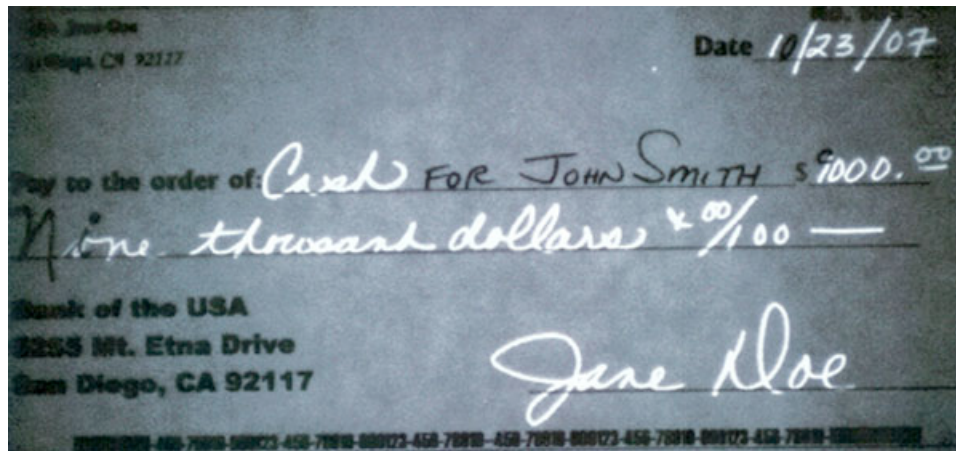
Since documents are part of daily life, forensic document examiners work a wide variety of cases. Forensic document examiners are called to investigate the authenticity of documents in situations such as:

- forgeries
- counterfeiting
- identity theft
- fraud
- suicides
- homicides
- bank robberies
- kidnappings
- extortion
- stalking
- contested wills
- contested contracts
- medical malpractice
- title/deed lawsuits

Forensic document examiners are most frequently asked to resolve questions of authorship. Is the signature on the mortgage loan genuine? Who wrote the anonymous note? Did the deceased sign the will? By comparing documents found at a crime scene to a suspect's known writing samples, the forensic document examiner can help confirm who wrote the note and include or exclude suspects from the investigation.

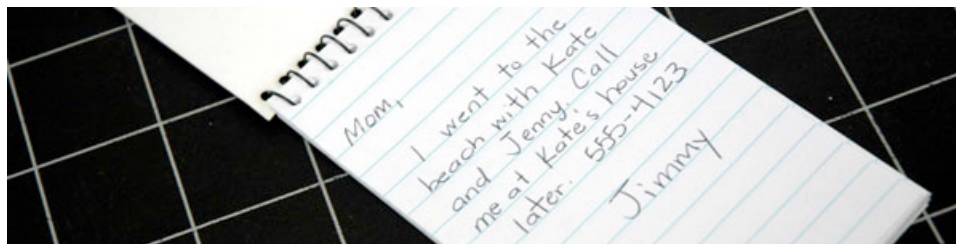
Ransom Note Nabs Kidnapper

A 1956 kidnapping case from Long Island, New York, helps illustrate the key role forensic document examination can play in an investigation. In this case, a one-month-old child was taken from his home and a ransom note was

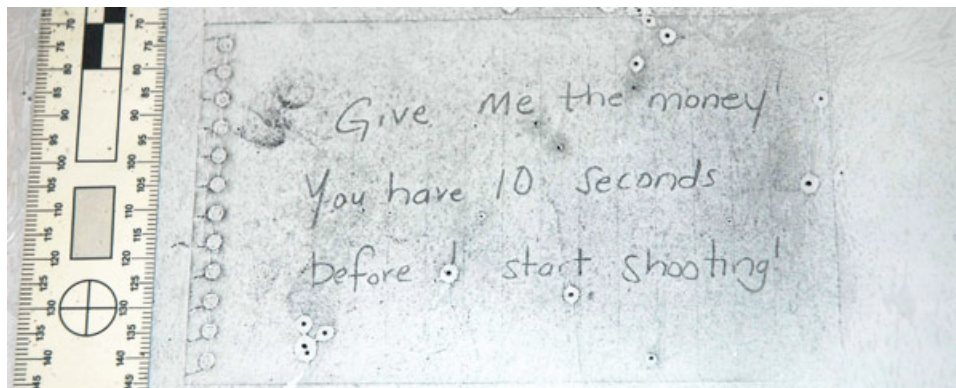


Same altered check viewed with infrared radiation (Courtesy of Marie Durina)

Documents in a suspect's possession may also reveal clues from hidden impression evidence (also known as indented writing) that could link a suspect to a crime. For instance, did the bank robbery suspect write the hold-up note on top of another piece of paper that now contains impression of that text?



A notebook found with suspect's personal effects. (Courtesy of Marie Durina)



The same notebook when analyzed with an Electrostatic Detection Device (EDD) reveals invisible impressions of the robbery demand note. (Courtesy of Marie Durina)

Examiners can also identify the materials, inks and even the type of office equipment or writing implements used to produce the document. This is especially useful in fraud cases because these details can identify the time frame in which a document was created. For instance, if analysis of the document's paper reveals a substance that was not used in paper manufacturing during the time frame in question, the document, piece of art, or historical record would be demonstrated to be fraudulent.

How It's Done

Evidence That May Be Examined

Questioned material may consist of identification cards, contracts, wills, titles and deeds, seals, stamps, bank checks, handwritten correspondence, machine-generated documents (such as those from photocopiers, fax machines, and printers), currency and electronic documents. In some circumstances, graffiti and digital signatures may be examined; however, the client should be aware that the examination of these types of evidence can be problematic.

Documents that don't contain visible identifiable marks may contain valuable impression evidence if they were underneath other documents when the writing was performed. Even documents that were shredded or burned may prove useful if reconstructed.

In addition, writing instruments, rubber stamps, envelopes and makes/models of office equipment in the suspect's possession may be collected by the investigator. In digital documents, evidence could even be culled from the metadata of electronic signature files, providing information such as who the author is and when the document was written.

Collecting the Known and Unknown

When conducting examinations, forensic document examiners must have **known specimens** to which they compare the material in question. These samples may come from any number of known sources, such as a particular ink manufacturer or machine.

In cases involving handwriting, samples are usually divided into two types: **requested writing specimens** and **collected writing specimens**. Requested specimens are writings dictated by the investigator to the writer. These specimens are created under carefully controlled conditions, with the writer being closely monitored. Collected writing specimens, however, are writings that were completed by the subject prior to the investigation. Good

sources of writing specimens may include items such as cancelled checks, letters, diaries, signed receipts, medical records, real estate contracts, tax records or other signed legal documents.

Who Conducts the Analysis

The analysis should be performed by a qualified forensic document examiner, preferably one who is a member of a well-established professional association such as the American Board of Forensic Document Examiners (ABFDE) or the American Society of Questioned Document Examiners (ASQDE). Membership requirements for these associations vary; however, an examiner typically must have completed a two-year, full-time training program under the guidance of a qualified forensic document examiner. To maintain membership in good standing and keep their skills current, examiners are required to complete continuing education.

How and Where the Analysis Is Performed

Forensic document examiners either work as private examiners within their own laboratory, or for publicly funded laboratories. If an agency does not have questioned documents analysis capabilities, investigators may opt to send the evidence to a nearby lab, or retain a private examiner.

The techniques and tools used in forensic document examinations leverage well-established principles of physics and chemistry. A typical Questioned Documents unit in a crime laboratory is equipped with microscopes, digital imaging instrumentation, infrared and ultraviolet light sources, video analysis tools and specialized equipment including electrostatic detection devices (EDD) and materials to perform analytical chemistry.

Many forensic document examiners use only non-destructive techniques that use light and/or electrostatics to examine documents for indented impression evidence or ink differentiation. However, a few examination techniques, such as liquid chromatography, are considered destructive because they require removal of small samples of ink from the questioned documents. These types of examinations may be sent off to laboratories that specialize in this type of ink analysis.

For analyses of documents created by typewriters, fax machines, or printers, examiners may rely on various databases created for comparison purposes. During handwriting analyses, examiners compare samples provided from particular populations. Certain agencies, such as the U.S. Secret Service and the German Federal Police, maintain larger databases. For example, the Forensic Information System for Handwriting (FISH) maintained by the U.S.

Secret Service Forensic Laboratory contains handwriting samples from tens of thousands of writers.

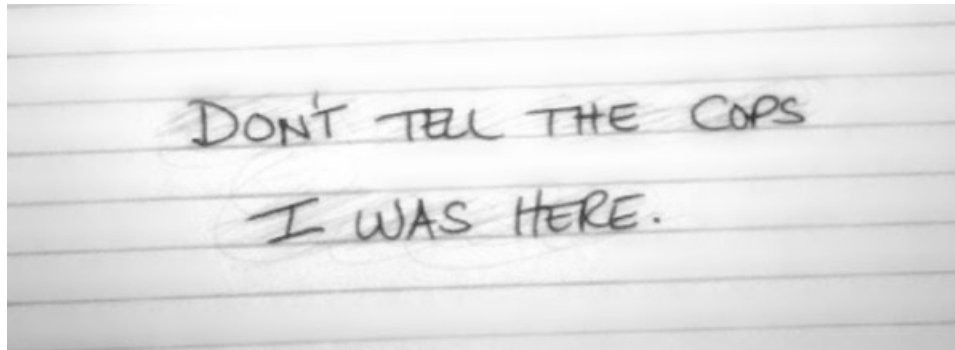
Revealing text from indented impressions – Documents that may contain indented impressions not visible to the naked eye can be visualized through the use of an Electrostatic Detection Device (EDD) such as the Electrostatic Detection Apparatus (ESDA). An EDD uses applied charges and toner to visualize areas of indented writing, making them visible to the eye. The ESDA uses the principle that indented areas of the document carry less negative charge than surrounding areas. This causes the toner used in the EDD to be attracted to these areas, revealing indentations that are present.

Using this technique, indented impressions have been recovered from up to seven layers of paper beneath the original writings. Research has demonstrated that impressions can be successfully visualized from documents up to 60 years old, provided the papers are not mishandled or stored improperly.

Detecting alterations, obliterations, erasures and page substitutions – Alterations, obliterations and erasures not visible to the human eye can often be detected through use of photography and other imaging devices that utilize ultraviolet and infrared wavelengths of light. Using radiation filtered at various wavelengths, an imaging instrument such as a video spectral comparator (VSC) can reveal writing that has been added with a different ink, or has been altered or removed by exploiting variations in the way different inks respond to different wavelengths of light. For example, under certain light sources combined with an infrared filter, a document containing information written in ink that has faded over time may be enhanced or processed to appear darker and therefore more legible.



Obliterated note viewed with visible light. (Courtesy of Marie Durina)



Same note viewed with infrared radiation. (Courtesy of Marie Durina)

Determining individual dye components – An examination called liquid chromatography can be conducted to identify the chemical composition of inks on a document. In this technique, a small cutting from the questioned document is dissolved in a solvent and analyzed. This is one of the few destructive techniques employed by the document examiner. The inks can be compared to the International Ink Library, a database maintained by the U.S. Secret Service that contains data on more than 9,500 inks that have been manufactured since 1920.

Typewritten and machine-printed documents – Documents created on a typewriter or printed with ink jet, laser printers, fax machines and photocopiers may be sourced to a particular make or model, or even to a specific machine. The printing process used to prepare documents can also be identified. When possible, the examiner should obtain known standards and any available accessories from the machine in question and the machine itself should be submitted for examination.

Seals and stamps – Questioned documents bearing rubber stamp impressions, embossed seals, watermarks, or other mechanically printed marks may be submitted for examination. When possible, it is best to provide the examiner with any suspected devices associated with the questioned document that may have been involved in its preparation. This includes writing instrument(s), papers, or other substrates, rubber stamp(s), sealing devices (such as notary seals), printing devices or other mechanisms.

To illustrate the value of a manufacturer's mark, consider a 1989 case when a young girl was kidnapped and murdered. Investigators called in forensic document examiners to examine the plastic garbage bag in which the victim was found. Minute markings created by the heat-seal process used in manufacturing such bags enabled investigators to determine that the bag was manufactured on the same machine within seconds of other bags found in the parents' house. This was key evidence that resulted in the conviction

of the girl's mother for murder. (Source: **WORLD OF FORENSIC SCIENCE**, ©2006 Gale Cengage.)

Examination of handwriting — When a sufficient amount of writing from two different people is closely examined, there are always identifiable differences. Comparisons of writing samples take into consideration a wide variety of handwriting characteristics including word and letter spacing, slant or slope, speed, pen position, use of capitalization, embellishments, legibility, use of punctuation, and proportion of letters and other attributes.

For example, one person may form the letter “O” in a clockwise motion, while another may form the same letter in a counter-clockwise motion. A particular writer may form the letter “M” using an upward-moving “arch” formation (similar to the McDonald’s Restaurant sign), while another prefers to make a “garland” form of “M”, forming this letter with a “U” motion to resemble the garland on a Christmas tree. Document examiners take into account the various combinations of features present within the writing sample as a whole. In addition, examiners look for features such as hesitations in the natural flow of writing, possible retouching or unnatural tremors. These may indicate that an unnatural writing process (e.g., simulation or disguise) has been employed.

No one writes with machine-like precision every time, and variations are evident in a person’s handwriting even within the same document. For example, if a person writes an entire page of signatures, each one will vary slightly. A trained forensic document examiner can discriminate between natural variations in a writer’s own handwriting and significant differences denoting different writers.

To conduct handwriting comparisons, the investigator should obtain known writing samples that are similar in character to the document in question. If it is written in cursive, it should be compared to known cursive writing. If it contains upper- and lower-case letters, the known writings must also contain upper- and lower-case letters. Wherever possible, the investigator should also obtain known writing containing similar combinations of letters and numbers seen in the questioned documents. For comparison purposes, it is recommended that investigators obtain 20–30 repetitions of signatures, 15–20 repetitions of bank checks, 3–4 repetitions of entire written letters.

The investigator should also attempt to obtain known writing that is prepared around the same time period as the questioned writing. This is particularly important in cases involving writing from young people (up to mid-teens), as writing formation may still be at a developmental stage, and by elderly persons, as writing may deteriorate with age or illness.

FAQs

What kind of results should be expected from a forensic document examination?

Results obtained often depend upon the quality and quantity of the evidence submitted. If a sufficient amount of evidence is submitted, an examiner will reach a conclusion that may range from identification (a definitive determination of authorship or source) to elimination (a definitive determination of non-authorship or from another source). If no determination can be made based on the evidence, the examiner will issue an inconclusive result. Most laboratories also permit a broader range of conclusions, called qualified conclusions, that fall somewhere in between the definitive conclusions of identification or elimination.

Many practitioners also choose to provide a defining description of the results of their examination. For instance, for a handwriting exam, an identification may be phrased, "The evidence very strongly supports the proposition that the questioned writing was written by the writer of the specimens."

What are the limitations of forensic document examination?

The examination of questioned documents may be hampered or limited by the following factors:

Non-original evidence (such as photocopies or faxes) submitted for examination. Every time a document is subjected to a copying process, a small amount of information is lost. Original documents may bear defects, flaws or characteristics that are not reproduced in a copy. Multi-generational copies (i.e., copies of copies) may be of insufficient quality for examination and comparison. It may even result in the examiner being unable to render a conclusion.

Insufficient quantity of questioned material. If there is not enough material for an adequate examination, the examiner will most likely be unable to render a definitive conclusion.

Insufficient quality. If the quality of either the questioned document or the known samples is not sufficient for proper examination, the examiner will likely be unable to render a definitive conclusion. Examples include documents that have been burned to ashes or cross-cut shredded,

documents that are multi-generation copies or faxes, or documents containing writing that is too distorted or disguised (as discussed below).

Insufficient known specimens submitted for comparison. This refers to situations where there is not enough known writing, or the samples are inadequate, poor-quality or machine-printed and not suitable for comparison.

Lack of comparability between the questioned documents and the known samples. The examiner must be able to compare “apples to apples” as the saying goes. For instance, the specimen material must be of the same type of writing as the questioned material; uppercase entries can only be compared to uppercase, and cursive writing can only be compared to cursive writing. An examiner cannot determine the counterfeiting process by looking at only a photocopy of the suspected counterfeit. Likewise, the examiner cannot determine if an identification card is fraudulent unless a known standard is also submitted for comparison.

Lack of contemporaneous writings submitted for comparison. It is important to obtain known writing that is prepared around the same time frame as the questioned writing.

Distortion or disguised writing. The writing on the questioned document or the known sample may be too distorted or disguised. For example, graffiti on a wall may be considered distorted and cannot be compared to a suspect’s normal handwriting.

How is quality control and assurance performed?

To ensure the most accurate analysis of evidence, the management of forensic laboratories puts in place policies and procedures that govern facilities and equipment, methods and procedures, as well as analyst qualifications and training. Depending on the state in which it operates, a crime laboratory may be required to achieve accreditation to verify that it meets established quality standards. There are two internationally recognized accrediting programs focused on forensic laboratories: The American Society of Crime Laboratory Directors Laboratory Accreditation Board (<http://www.ascl-d-lab.org/>) and ANSI-ASQ National Accreditation Board / FQS (<http://www.forquality.org/>).

In disciplines such as forensic document examination, where testing requires analysts to compare specific details of two samples, quality control is achieved through technical review. This involves an expert or peer who reviews the test data, methodology and results to validate or refute the outcome. The Scientific Working Group on Document Examination

(SWGDOC) (<http://www.swgdoc.org/>) works to set quality guidelines for document examinations. These standards provide good practice for analysts.

Some of the examinations conducted in this forensic discipline are handled by private contractors, who should employ similar quality assurance techniques.

What information does the report include and how are the results interpreted?

At a minimum, all reports should include a detailed description of the evidence submitted for analysis, the examinations performed by the examiner, and the results of the examination. An explanation of the reasons for the examiner's conclusions, or any limitations, may also be included. In addition to the final reports, work notes are also maintained as part of the case file, and are subject to discovery by the courts. These may include photographic images or photocopies of the evidence submitted, work charts and sketches, communication logs and chain of custody documentation.

The format of reports is greatly influenced by where the document examiner is employed. Private practitioners have more freedom to choose their own formats and have greater flexibility in tailoring their reports to fit the case at hand. Government agency examiners, on the other hand, may be bound by their employer's procedures or policies.

Are there any misconceptions or anything else about forensic document examination that would be important to the non-scientist?

Forensic document examiners do not make any determination of the psychological state or personality of a suspect from their handwriting. This is a controversial practice conducted by a handwriting analyst or "graphologist" who is not associated with the practice of forensic document examination.

Common Terms

Understanding the common terminology used in questioned document examination is key to interpreting the examination results and testimony from expert witnesses.

Alteration – A modification made to a document by physical, chemical or mechanical means.

Collected Known Specimens/Standards – Documents created in the normal course of a person’s business activities or daily living. These typically reflect the true writing habits of the individual.

Contemporaneous Writing – Material that is written around the same time period as the document in question.

Cursive – A type of smooth, flowing handwriting where letters within a word are joined. This is produced when the writing instrument is not lifted after most strokes.

Disguised Writing – Deliberately altered writing intended to conceal the identity of the writer by attempting to change his or her writing habits.

Distorted Writing – Writing that appears not naturally executed, either as a result of voluntary effort such as in disguised writing, or as a result of involuntary factors such as physical illness or writing surface.

Document – Any material that contains marks, symbols, or signs—visible, partially visible, or invisible—that may convey a meaning or message.

Electrostatic Detection Device (EDD) – The generic term for equipment that uses electrostatic charge to visualize writing impressions such as indentations and erasures. The electrostatic detection apparatus or "ESDA" is the most commonly used device of this type for document examinations.

Forensic Document Examiner (FDE) – One who studies the details and elements of documents in order to identify their source or determine their authenticity. Also known as an “FDE” or “document examiner”.

Handwriting Identification – The attempt to verify a person’s handwriting by comparing a document in question to a known handwriting sample. This term is preferred over “handwriting analysis” which usually refers to those who attempt to determine the character traits of a person by examining handwriting samples.

Indented Impressions – The depressed area on the surface of a document that was created by the pressure of writing or a mechanical means of printing.

Individualizing Characteristic – Any mark commonly produced during the creation of a document that helps to identify its source.

Natural Writing – Writing executed in a habitual manner, without an attempt to control or alter its characteristics.

Obliterations – Any area of a document that has been purposely covered, usually by other writing, to attempt to mask the markings that lay underneath.

Questioned Document – A document, usually related to matters involving criminal or civil litigation, in which the originality, authenticity or background is disputed.

Request Exemplars or Requested Known Specimens/Standards – Writing specimens created by an individual at the request of an investigator. These are typically created by having the investigator dictate the text to the subject. Creation of exemplars is conducted under tightly controlled, monitored conditions.

Significant Difference – An individualizing characteristic that is consistently divergent between questioned and known items.

Significant Similarity – An individualizing characteristic that is common between questioned and known items.

Video Spectral Comparator (VSC) – A digital imaging instrument manufactured by Foster + Freeman that employs combinations of light sources and filters to examine document evidence under various wavelengths of radiation ranging from ultraviolet to the infrared regions of the electromagnetic spectrum. This device is typically used to discriminate between different inks and reveal alterations or obliterations, visualize security features in papers, and examine characteristics such as watermarks and fiber disturbances using transmitted, direct, or oblique light.

Resources & References

You can learn more about this topic at the websites and publications listed below.

Resources

Scientific Working Group for Forensic Document Examination (SWGDOC)
<http://www.swgdoc.org/>

American Board of Forensic Document Examiners (ABFDE)
<http://www.abfde.org/>

American Society of Questioned Document Examiners (ASQDE)
<http://www.asqde.org/>

Southwestern Association of Forensic Document Examiners (SWAFDE)
<http://www.swafde.org/>

Southeastern Association of Forensic Document Examiners (SAFDE)
<http://www.safde.org/>

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Forensic Evidence Admissibility and Expert Witnesses

How or why some scientific evidence or expert witnesses are allowed to be presented in court and some are not can be confusing to the casual observer or a layperson reading about a case in the media. However, there is significant precedent that guides the way these decisions are made. Our discussion here will briefly outline the three major sources that currently guide evidence and testimony admissibility.

The *Frye* Standard – Scientific Evidence and the Principle of General Acceptance

In 1923, in *Frye v. United States*^[1], the District of Columbia Court rejected the scientific validity of the lie detector (polygraph) because the technology did not have significant general acceptance at that time. The court gave a guideline for determining the admissibility of scientific examinations:

*Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while the courts will go a long way in admitting experimental testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be **sufficiently established to have gained general acceptance** in the particular field in which it belongs.*

Essentially, to apply the “*Frye* Standard” a court had to decide if the procedure, technique or principles in question were generally accepted by a meaningful proportion of the relevant scientific community. This standard prevailed in the federal courts and some states for many years.

Federal Rules of Evidence, Rule 702

In 1975, more than a half-century after *Frye* was decided, the Federal Rules of Evidence were adopted for litigation in federal courts. They included rules on expert testimony. Their alternative to the *Frye* Standard came to be used more broadly because it did not strictly require general acceptance and was seen to be more flexible.

[1] 293 Fed. 1013 (1923)

The first version of Federal Rule of Evidence 702 provided that a witness who is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion or otherwise if:

- a. the expert's scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue;
- b. the testimony is based on sufficient facts or data;
- c. the testimony is the product of reliable principles and methods; and
- d. the expert has reliably applied the principles and methods to the facts of the case.

While the states are allowed to adopt their own rules, most have adopted or modified the Federal rules, including those covering expert testimony.

In a 1993 case, *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, the United States Supreme Court held that the Federal Rules of Evidence, and in particular Fed. R. Evid. 702, superseded *Frye's* "general acceptance" test.

The *Daubert* Standard – Court Acceptance of Expert Testimony

In *Daubert* and later cases^[2], the Court explained that the federal standard includes general acceptance, but also looks at the science and its application. Trial judges are the final arbiter or "gatekeeper" on admissibility of evidence and acceptance of a witness as an expert within their own courtrooms.

In deciding if the science and the expert in question should be permitted, the judge should consider:

- What is the basic theory and has it been tested?
- Are there standards controlling the technique?
- Has the theory or technique been subjected to peer review and publication?
- What is the known or potential error rate?
- Is there general acceptance of the theory?
- Has the expert adequately accounted for alternative explanations?
- Has the expert unjustifiably extrapolated from an accepted premise to an unfounded conclusion?

The *Daubert* Court also observed that concerns over shaky evidence could be handled through vigorous cross-examination, presentation of contrary evidence and careful instruction on the burden of proof.

[2] The "Daubert Trilogy" of cases is: **DAUBERT V. MERRELL DOW PHARMACEUTICALS, GENERAL ELECTRIC CO. V. JOINER** and **KUMHO TIRE CO. V. CARMICHAEL**.

In many states, scientific expert testimony is now subject to this *Daubert* standard. But some states still use a modification of the *Frye* standard.

Who can serve as an expert forensic science witness at court?

Over the years, evidence presented at trial has grown increasingly difficult for the average juror to understand. By calling on an expert witness who can discuss complex evidence or testing in an easy-to-understand manner, trial lawyers can better present their cases and jurors can be better equipped to weigh the evidence. But this brings up additional difficult questions. How does the court define whether a person is an expert? What qualifications must they meet to provide their opinion in a court of law?

These questions, too, are addressed in **Fed. R. Evid. 702**. It only allows experts “qualified ... by knowledge, skill, experience, training, or education.” To be considered a true expert in any field generally requires a significant level of training and experience. The various forensic disciplines follow different training plans, but most include in-house training, assessments and practical exams, and continuing education. Oral presentation practice, including moot court experience (simulated courtroom proceeding), is very helpful in preparing examiners for questioning in a trial.

Normally, the individual that issued the laboratory report would serve as the expert at court. By issuing a report, that individual takes responsibility for the analysis. This person could be a supervisor or technical leader, but doesn't necessarily need to be the one who did the analysis. The opposition may also call in experts to refute this testimony, and both witnesses are subject to the standard in use by that court (*Frye, Daubert, Fed. R. Evid 702*) regarding their expertise.

Each court can accept any person as an expert, and there have been instances where individuals who lack proper training and background have been declared experts. When necessary, the opponent can question potential witnesses in an attempt to show that they do not have applicable expertise and are not qualified to testify on the topic. The admissibility decision is left to the judge.

Additional Resources

Publications:

Saferstein, Richard. **CRIMINALISTICS: AN INTRODUCTION TO FORENSIC SCIENCE**, Pearson Education, Inc., Upper Saddle River, NJ (2007).

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