



A Simplified Guide To Footwear & Tire Track Examination

Introduction

When a perpetrator hides evidence of a crime, it's commonly called "covering their tracks." For instance, an individual burglarizes a home and uses a cloth to wipe away any fingerprints before leaving. He thinks he has covered his trail; but he may not realize the impressions his shoes or tires make could also be used to link him to the scene of the crime.

These footwear and tire track impressions are referred to as "pattern evidence" because the impressions form a unique pattern. Shoes and boots leave prints and impressions specific to their particular brand, style and size. The tread on each tire of a vehicle may provide investigators with similar information.



(Courtesy of John Black, Ron Smith & Associates)

Through searchable databases compiled by manufacturers, the FBI and other agencies, examiners can attempt to identify the type of footwear or tire that made an impression. With this information, investigators can research which retailers sell a particular shoe, or which vehicles are equipped with a particular tire. This evidence can then be used to help determine if a suspect was present at a crime scene or exclude a person of interest from the investigation.

Principles of Footwear & Tire Track Examination

The basic theory behind footwear and tire track analysis is that, much like fingerprints, shoes and tires may leave behind either prints (referred to as "imprints") or impressions that can be examined by investigators. The type

of evidence left behind depends largely on the type of surface traveled. For example, a shoe will leave an impression in loose sand, but on a hard surface like concrete or linoleum, it will leave an imprint. These imprints or impressions can be compared to a suspect's shoe or a vehicle's tire to determine if the shoe or tire is the same one that left the impression.

As shoes and tires are used, their physical features change over time. This is called wear, and is often reflected in the imprint or pattern left behind. In the case of a tire track, if a vehicle is out of alignment, the right front tire may be heavily worn on the outer edge, leaving a unique wear pattern. A forensic examiner can use that wear pattern along with the tread pattern and information gained from database searches to positively match that impression to the suspect's vehicle.

During the examination of a crime scene or other location, if footwear or tire track evidence is found and collected, examiners can compare these unknown impressions to known impressions, impressions connected to other crimes and impression evidence stored in law enforcement databases. To do this, examiners use three main characteristics to analyze the imprints and impressions: class, individual and wear.

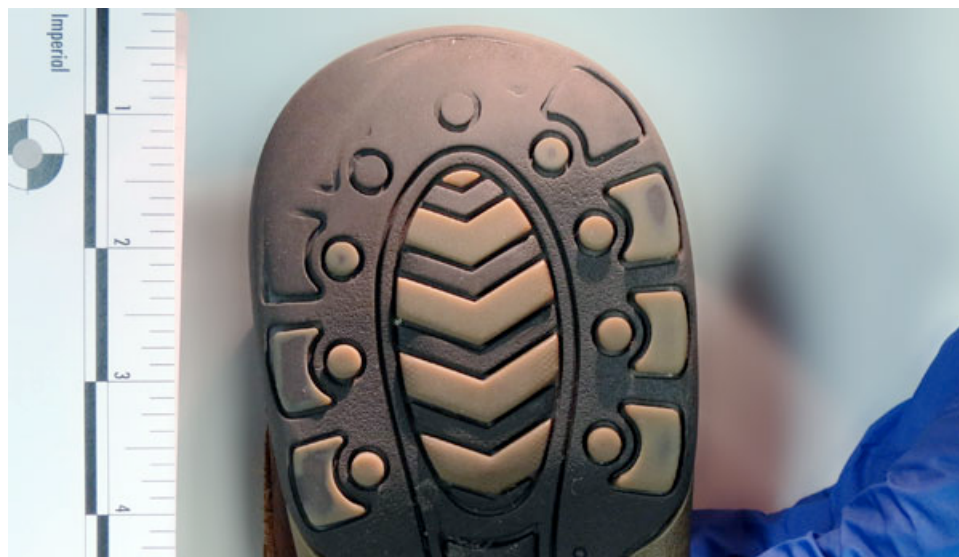
Class characteristics result from the manufacturing process and are divided into general and limited. General class characteristics include those that are standard for every item of that make and model. Limited characteristics refer to variations that are unique to a certain mold. For example, two tires of the same brand, model and size will have identical tread design and dimensions, but may have slight differences due to imperfections in the molds used during manufacturing.



Enlarged image of a tire tread shows characteristics unique to the mold used to create this tire (red arrows). (Courtesy of John Black, Ron Smith & Associates)

Individual characteristics are unique aspects of a particular shoe or tire that result from use, not the manufacturing process. These could be from damage such as a cut, gouge or crack, or a temporary alteration like a stone or twig stuck in the tread.

Wear characteristics result from the natural erosion of the shoe or tread caused by use. Specific wear characteristics include the wear pattern, the basic position of tread wear; the wear condition, the amount or depth of the wear; and where extreme, the damage to or destruction of the tread. For instance, the location and amount of tread loss on a particular brand and style of shoe will be different for each person wearing the shoe based on how and where they walk, and the length of time they have owned the shoe.



(Courtesy of NFSTC)

The FBI compiles and maintains the Footwear and Tire Tread Files database containing manufacturers' information and information from previously submitted evidence. This information can be used by examiners or investigators to determine the brand name and model of shoe or tire imprints and impressions found at crime scenes. The National Institute of Justice also maintains a list of forensic databases (<http://www.nij.gov/journals/258/forensic-databases.html>).

Why and when is footwear & tire track examination used?

Footwear and/or tire track evidence can be found at many crime scenes including breaking and entering, assault, hit and run, armed robbery, rape and homicide. For instance, shoeprints may be found on the tile in the

entryway of a residential break-in, or tire tracks found along a dirt road near a murder victim. At some point in time, the perpetrator arrived at the scene, committed the crime, and then left the scene on foot or in a vehicle.

This type of evidence can provide valuable information to investigators including:

- Where the crime occurred
- The number of parties or vehicles present
- The direction a person may have traveled before, during or after the crime
- Whether a person was on foot
- Other crime scenes connected to a perpetrator

One of the most famous cases involving shoeprints was the 1995 O.J. Simpson murder trial. The bloody shoeprints found on the walkway in front of Nicole Brown Simpson's condominium received worldwide media attention. Upon forensic examination, they were identified as imprints from the sole of a size-12 Bruno Magli shoe.

Information from the manufacturer indicated that only 299 pairs of this size-12 shoe were sold in the U.S. Two of these pairs were sold at a Bloomingdale's store in New York where Simpson was known to have shopped. However, Simpson denied ever owning a pair of these shoes. It wasn't until the 1996 wrongful death civil trial that pictures surfaced of Simpson at a Buffalo Bills football game, wearing a pair of black Bruno Magli shoes of the same style that left the bloody shoeprints. This was key evidence in the civil trial that led to the judgment against Simpson.

How It's Done

Evidence that May be Examined

Footwear and tire tracks can be deposited on almost any surface, from paper to the human body. Prints are divided into three types: visible, plastic and latent.

A **visible** print is a transfer of material from the shoe or tire to the surface. This type can be seen by the naked eye without additional aids. For example, bloody shoe prints left on flooring or tracks left by muddy tires on a driveway.



Bloody shoeprints are visible on tile flooring. (Courtesy of John Black, Ron Smith & Associates)

A plastic print is a three-dimensional impression left on a soft surface. This includes shoe or tire tracks left in sand, mud or snow.



Plastic shoeprint left in sand. (Courtesy of Aubrey Askins, Tacoma Police Department)

A **latent** print is one that is not readily visible to the naked eye. This type is created through static charges between the sole or tread and the surface. Examiners or investigators use powders, chemicals or alternate light sources to find these prints. Examples include shoeprints detected on a tile or hardwood floor, window sill, or metal counter, or tire tracks detected on road surfaces, driveways or sidewalks.



Dust impression left on a masonite surface, illuminated with oblique lighting. (Courtesy of Scott Campbell, Ron Smith & Associates)

How Samples are Collected

Examiners use several methods for collecting footwear and tire track evidence depending on the type of impression found. For impressions in soil, snow or other soft surfaces, casting is the most commonly used collection method. For imprints, examiners generally try to collect the entire object containing the imprint, such as a whole sheet of paper or cardboard with a shoe print. When that is not possible, for instance, if the print is on a bank counter, the examiner would use a lifting technique to transfer the imprint to a medium that can be sent to the laboratory.



Casts are created of footwear impressions to preserve them and allow for comparison and analysis. (Courtesy of NFSTC)

As with any evidence found at a crime scene, shoeprints and tire tracks must be properly documented, collected and preserved in order to maintain the integrity of the evidence. Impression evidence is easily damaged, so steps must be taken to avoid damage to the evidence. This includes securing and documenting the scene prior to collecting any evidence.

In the case of impression evidence, general photographs of the evidence location in relation to the rest of the scene are taken, along with high-resolution images of the individual imprints or impressions. Examiners may use alternate light sources or chemical enhancers to capture as much detail as possible, especially with latent imprints.

Properly photographing impressions is crucial. Since there is only a slight difference between different shoe sizes, if the photographs are not taken at a 90° angle to the impression, then the true size cannot be produced in order to compare to the actual shoe.

Whenever possible, impression evidence is collected as is and submitted to the laboratory for examination. For shoeprints and tire tracks that cannot be picked up, various lifting techniques are used to recover the evidence. These include:

Adhesive lifter - a heavy coating of adhesive lifts the imprint from smooth, non-delicate surfaces such as tile or hardwood floors, metal counters, etc. It is usually used in conjunction with fingerprint powders.

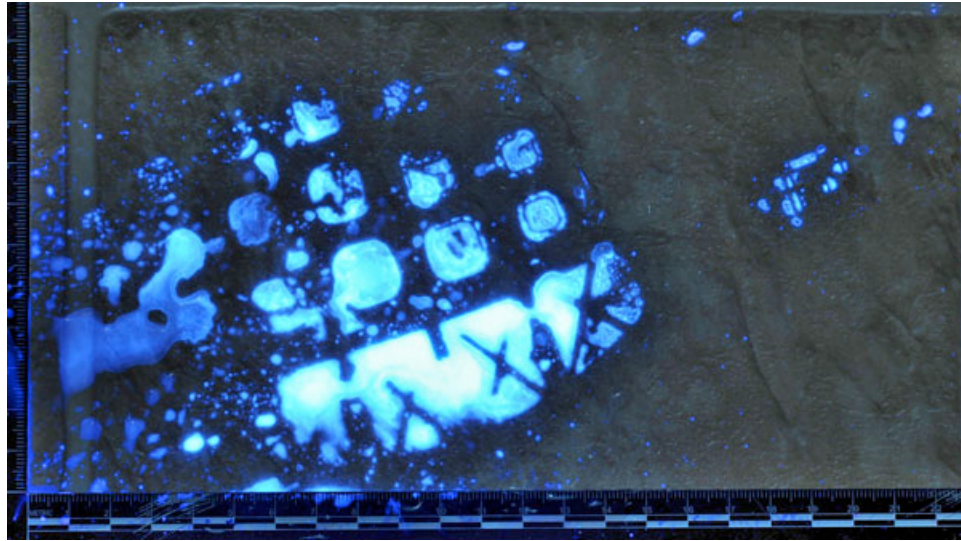
Gelatin lifter - a sheet of rubber with a low-adhesive gelatin layer on one side that can lift prints from almost any surface, including porous, rough, curved and textured surfaces. It is less tacky and more flexible than an adhesive lifter, allowing it to pick up a dusty shoeprint on a cardboard box, for example, but not tear the surface of the box.

Electrostatic dust-print lifting device - a tool that electrostatically charges particles within dust or light soil, which are then attracted and bonded to a lifting film. This method is best for collecting dry or dusty residue impressions on almost any surface, even the skin of a cadaver.

Any plastic, or three-dimensional, footwear or tire impressions can be collected by casting. Casting uses a powdered stone material, such as dental stone, that can be mixed with water and poured into the impression. When it dries, this method creates a three-dimensional model of the impression.

Imprints and impressions may be further processed to enhance or bring out additional minute details. For example, a digital enhancement program such as Adobe Photoshop® can be used to improve the quality of a photographed tire track. Fingerprint powders and chemical stains or dyes can enhance

image color or increase the contrast against the background. This enables lifted or casted evidence to be photographed or scanned.



A faint bloody shoe print on linoleum is enhanced by treatment with a chemical, BLUESTAR®, to allow a more detailed photograph to be taken of the evidence. (Courtesy of Erik Savicke, Boston PD)

Comparison samples are usually taken from suspects or suspect vehicles. Shoe samples should be packaged to avoid cross-contamination and tire samples should remain on the vehicle.



A reference print from a tire is captured by inking the tire and driving over paper. (Courtesy of John Black, Ron Smith & Associates)

Who Conducts the Analysis

Evaluation and comparison of impression evidence should be performed by a well-trained footwear and tire track examiner. Typically these professionals have received extensive training on footwear and tire manufacturing, evidence detection, recovery, handling and examination procedures, laboratory and photography equipment and procedures, courtroom testimony and legal issues, and casework.

The Scientific Working Group on Shoeprint and Tire Tread Evidence (SWGTTREAD) (<http://www.swgtread.org>) has a published standard that discusses the minimum qualifications and training for footwear/tire track examiners. Additionally, the International Association for Identification (IAI) (<http://www.theiai.org/>) offers a recommended course of study for footwear and tire track examiners that takes participants through more than 550 hours of training. The IAI also certifies footwear (but not tire track) examiners.

How and Where the Analysis is Performed

Detection, documentation, photography, and collection of imprints and impressions occur in relation to crime scenes of many types. Analysis of impression evidence is typically performed at a public crime laboratory or private laboratory by experienced examiners.

Evidence Submission and Examination

Ideally, the suspect's shoes and/or tires are submitted to the lab along with the collected evidence. Examiners will use the submitted shoes and/or tires to make test standards, impressions of a known source, which can then be compared to the collected evidence. This is usually done using transparency overlays or side-by-side comparisons.

For example, in a case from Florida, a bloody shoe print was found on the carpet in the home of a murder victim. The print indicated that there was a hole in the shoe that left the print. Investigators collected and made test prints of the shoes from individuals known to be at the scene near the time of the murder. Footwear examiners were able to identify the perpetrator by overlaying the bloody shoeprint from the crime scene with the test print made from the suspect's shoe.

In some cases, an investigator may be asked to submit shoes or tires of other individuals for exclusion purposes, such as from a cohabitant of a home or from a first responder to a crime scene.

Tools and Techniques

During the examination and comparison, examiners use tools such as dividers, calipers, special lighting and low magnification. Examiners measure the various elements within the tread design as well as the length and width of the impressions, and then compare those measurements to what is seen in the crime scene print or impressions. Low magnification and special lighting are sometimes used to determine if various characteristics

are accidental or something that was created during the manufacturing process.

Examiners perform side-by-side comparisons by placing the known shoe or tire alongside the crime scene print so that corresponding areas can be examined. Test prints are also compared to the crime scene print. Digital images on double or triple computer monitors can also be used during the comparison.

Resources and References

Investigators or examiners often use searchable databases containing reference files of shoe outsoles and tire treads to determine the brand/model of a shoe or tire. The FBI, private consultants and fee-based commercial systems maintain databases with tens of thousands of prints. Often investigators can contact the manufacturer directly to obtain information and images for a specific shoe or tire.

The FBI's Criminal Justice Information System (CJIS) maintains the Footwear and Tire Tread Files database. The SWGTREAD website <http://www.swgtread.org/> contains links, resources, information and videos to assist investigators and examiners.

Some agencies use databases to store crime scene images of shoes and tires, and to search and compare crime to crime. Searching these databases does not find potential "matches" as automated fingerprint identification systems can, but returns tread design "look-alikes" for footwear and tire tread.

FAQs

What kind of results can be expected from the analysis of footwear and tire tracks?

Footwear/tire track examination results are presented in a report that presents the examiner's observations and conclusions, and may also include supporting details, such as the level of association between the suspect's shoe or tire and the print or impression from the crime scene.

Forensic footwear and tire track examinations result in one of four possible determinations: an individualization, an elimination, inconclusive results or an association.

An **individualization** is when the class, wear and individual characteristics of the collected impression and the known shoe or tire sufficiently match with no unexplainable differences.

An **elimination (exclusion)** is when the class, wear and/or individual characteristics do not sufficiently match between the collected impression and the known shoe/tire.

An **inconclusive** result occurs when there is not sufficient quality or quantity of information from the questioned impression to reach a meaningful scientific conclusion.

An **association (likelihood)** can be drawn when the class, wear and some individual characteristics agree between the collected impression and the known shoe/tire, but are not sufficient to be certain of a match. Results can range from *likely* to *could have*, to *similar but lacking sufficient detail to be conclusive*.

What are the limitations of the analysis?

The analysis essentially requires two things: 1) the print, track or impression evidence, and 2) comparison shoes or tires. The analysis usually depends on the condition of the evidence. If the evidence has been collected properly, and if the substrate (soil, snow, etc.) retains the minute features of the track, a definitive opinion can be reached.

How is quality control and quality 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, and 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 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 footwear and tire track examination, where testing requires analysts to compare specific details of two samples, quality control is achieved through technical review and verification of conclusions. This involves an expert or peer who reviews the test data, methodology and results to validate or refute the outcome. The guidelines published by the Scientific Working Group for Shoeprint and Tire Tread Evidence (SWGTTREAD) <http://www.swgtread.org/> state that all footwear and tire track cases should be technically reviewed and verified by a second independent qualified examiner.

Some of the examinations conducted in this forensic discipline are handled by private contractors. These contractors can identify the quality control and quality assurance steps they employ.

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

The report typically states what was submitted for analysis and the conclusion of the analysis: individualization, elimination (exclusion), inconclusive, or association (likelihood). Some reports from private laboratories include photographs of the examination and conclusion of the results.

Are there any misconceptions or anything else about footwear and tire track examination that might be important to the non-scientist?

While television crime dramas might give the impression that all the evidence at a scene can and will be identified, in practice, many opportunities to collect footwear and tire track evidence can easily go overlooked if the impressions are not readily apparent. Moreover, while shoe prints can be very difficult to protect and can easily be disturbed by first responder traffic at a crime scene, they can often still be located after subjected to some foot traffic.

Another misconception involves tire track examination. On some crime dramas, a detective snaps a photo of a tire track on his cell phone and, using a database or app, instantly retrieves the make/model/number of the tire. In reality, there is currently no automated method for matching tread patterns. The patterns must be meticulously photographed and documented, then compared manually using computer databases and sometimes printed reference books. The process is time consuming and even if the tire can be identified, it is just part of the work needed to connect the tire track to a particular car or individual.

Common Terms

Adhesive lifter – Any variety of adhesive-coated materials or tapes used to lift fingerprints or footwear impressions. Primarily used to lift powdered impressions from non-porous surfaces.

Cast -

1. A method of making a mold by first making a three-dimensional model of a shoe or tire and then forming the mold from that model.
2. The filling of a three-dimensional footwear or tire track impression with material that takes on and retains the characteristics that were left in that impression by the footwear or tire.
3. A method used in the lifting of two-dimensional footwear and/or tire impressions from rough surfaces.

Class characteristic – An intentional or unavoidable characteristic (such as physical shape, physical size, tread design/elements or wear position) that repeats during the manufacturing process and is shared by one or more other shoes or tires.

DOT number – Department of Transportation serial number assigned to every tire sold in the United States; it gives information regarding the manufacturer, size and date of manufacture of the tire.

Electrostatic dust print lifter – A system that applies a high-voltage electrostatic charge on a piece of lifting film, causing dust or residue particles from a print to transfer to the underside of the lifting film.

Elimination (exclusion) – An elimination is established when the class, wear and/or individual characteristics present in the questioned impression do not agree with those in the known shoe/tire.

Elimination impressions – Test impressions taken from the shoes and tires of first responders and other known individuals for the purpose of discerning these impressions from the questioned crime scene impressions.

Identification – The positive association of an impression as having been made by a single shoe, to the exclusion of all others.

Inconclusive – A questioned impression that does not exhibit sufficient quality and/or quantity of information may be deemed inconclusive. This indicates that a meaningful scientific conclusion cannot be reached.

Individual characteristic – Something unique about the footwear or tire tread that is not shared by any other shoe or tire—even those from the same production run. It could result from damage or some temporary alteration, such as a stone caught in the tread.

Latent – A type of print that is not visible to the naked eye.

Lift – To transfer an impression from its original surface for the purpose of recovering it from the crime scene and for providing better contrast.

Negative impression – An impression that results when the contact area of a shoe or tire removes residue (such as dust, paint or some spilled substance) from a surface, leaving behind a “clean” image of the print in the residue.

Outsole – The bottom portion of the shoe that provides durability and traction on a surface. It is the outer sole of the shoe, from the toe to the beginning of the heel, but exclusive of the heel itself. With leather soles the grain side of the leather is almost always used for the bottom face or exposed part. In a looser or broader sense, “bottom” may include insole and/or midsole.

Plastic – A type of print that is three-dimensional.

Positive impression – An impression that results when a shoe or tire deposits material onto a surface.

Stone hold – A characteristic created when a tread captures and holds a loose stone. Stone holds are considered individual characteristics.

Tread – The designed part of the shoe or tire that comes into contact with the ground or road.

Wear characteristics – Changes in the surface of the shoe outsole or tire tread that are observable in the impression and/or known shoe or tire, and that reflect the erosion of the surface of the shoe outsole or tire tread.

Resources & References

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

Resources

International Association for Identification (IAI) Footwear Certification

<http://www.theiai.org/certifications/footwear/index.php>

Scientific Working Group on Imaging Technology (SWGIT)

<http://theiai.org/guidelines/swgit/index.php>

SWGIT GENERAL GUIDELINES FOR PHOTOGRAPHING FOOTWEAR AND TIRE

TRACK EVIDENCE Section 9

http://theiai.org/guidelines/swgit/guidelines/section_9_v1-2.pdf and

Section 10

http://theiai.org/guidelines/swgit/guidelines/section_10_v1-2.pdf

Scientific Working Group on Shoeprint and Tire Tread Evidence
(SWGTHREAD) <http://www.swgtread.org/>

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Colbry, D.; Cherba, D.; Luchini, J. Pattern Recognition for Classification and Matching of Car Tires, **TIRE SCIENCE AND TECHNOLOGY** 2005, 33(1), pp. 2–17.

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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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