# EXPERT TESTIMONY—RECENT DEVELOPMENTS IN THE RELEVANT LAW AND SCIENCE

# I. RECENT DEVELOPMENTS IN THE LAW

A. Pretrial Procedure

•

1. Closer judicial scrutiny of the preparation of expert reports under Federal Rule of Civil Procedure 26

Imwinkelried & Blumoff, Pretrial Discovery: Strategy and Tactics 2023-2024 Edition § 5:13 (2023); Greenbaum, Expert Witness Reports in Federal Civil Litigation: The Role of the Attorney in the Expert Witness Report's Preparation, 48 Hofstra L.Rev. 131 (2019)

> The expert's obligation to personally prepare a report that reflects his or her own expert reasoning. This obligation can be violated by the expert or the attorney who hired the expert.

(a) Violations by the Expert

Henderson v. Lockheed Martin Corp., 723 F.Supp.3d 1147 (M.D.Fla. 2024); Paulus & Ravi, "A Mess": Harvard Med School Professor Plagiarized in Expert Report, Judge Says, Harvard Crimson (Apr. 15, 2024). Harvard Medical School assistant professor Dipak Panigraphy was hired as an expert by the plaintiff's attorneys in a lawsuit against Lockheed Martin. The plaintiffs allege that the company's Orlando manufacturing facility released toxic chemicals into the area and thereby caused injuries, including cancer. Panigraphy filed a 500 page report supporting the plaintiff's theory of causation. However, on March 8, U.S. District Court Judge Ray Dalton, Jr., excluded the report on the ground that Panigraphy had engaged in extensive plagiarism in preparing the report. The report relied heavily on the work of the International Agency for Research on Cancer. The report contained citations to IARC publications but did not use quotation marks to indicate verbatim quotations. According to Judge Dalton, at his deposition Panigraphy "repeatedly outright refused to acknowledge the long swaths of his report that quote other work verbatim without any quotation marks at all . . . ."

(b) Violations by the Attorney Calling the Expert

--permissible types of attorney involvement in the preparation of the report

Explaining the requirements of Rule 26 to the expert

Providing the expert with the relevant case-specific facts and even leads as to relevant literature

Participating to a limited extent in the preparation of the report such as wordsmithing

--impermissible types of involvement

Types of misconduct

Intimidation

Ghost writing

Remedies for misconduct

Allowing broad-ranging cross-examination

Striking the expert's report

The practical problem of proving the attorney's misconduct

One view: the 2010 amendments to Rule 26 do not block a limited, generalized inquiry about the attorney's participation in the drafting process

A second view: the issue of the authorship of particular parts of the report is "off limits"

A third view: the scope of inquiry depends on the extent to which other evidence points to the possibility of substantial lawyer involvement in the preparation of the expert's report

2. A growing body of case law holding that the courts should relax the application of *Daubert* and Federal Rule of Evidence 702 at pretrial hearings on class certification and summary judgment

The analogy to bench trials

Article, Rigor or Reach? Strictness or Scope: The Continuing Battle Over the Parameters of the Supreme Court's *Daubert/Kumho* Reliability/Validation Test for the Admissibility of Expert Testimony, 88 Mo.L.Rev. 615 (2024)

the current split of authority

the significance of the judge's role as decisionmaker

the general policy argument that there is less risk that the judge will overvalue the expert testimony

the specific factor of the error rate—the judge's appreciation that proof of the witness's qualification and that of the reliability of the methodology are distinct foundational elements

the specific factor of general acceptance—the judge's realization that in the past once popular methodologies have subsequently been discredited

#### B. Evidence Law

1. The Witness's Qualification as an Expert

The increasing tendency of the courts to insist that the witness possess credentials enabling him or her to answer the "specific" question posed

2. The Witness's Major Premise, the Methodology

The distinction between foundational validity and validity as applied

The 2016 report of the President's Council of Advisors on Science and Technology; Article, The Admissibility of Scientific Evidence: Exploring the Significance of the Distinction Between Foundational Validity and Validity as Applied, 70 Syracuse L.Rev. 817 (2020)

Federal Rule 702(d): the reliable application of the methodology

the mechanical meaning of the requirement

the deeper, scientific meaning-the 2016 PCAST report

the argument that the methodology has never been applied to this type of fact situation

the need to identify the parameters of the validation tests used to establish foundational validity

the validation studies of probabilistic genotyping programs used to evaluate complex DNA mixtures

the 2016 PCAST summary of the studies: a minimum sample size, a maximum of three contributors, and the minor contributor accounting for at least 20% of the sample

United States v. Gissantaner, 417 F.Supp.3d 857 (W.D.Mich. 2019). Judge Neff's opinion in *Gissantaner:* a sample below the minimum size, plausible evidence that there were four contributors, and a minor contributor accounting for only 7% of the sample

The subsequent reversal of Judge Neff's decision. 990 F.3d 457 (6<sup>th</sup> Cir. 2021).

3. The Witness's Minor Premise, the Case-Specific Data

In Smith v. Arizona, 144 S.Ct. 1785, 219 L.Ed.2d 420 (2024), the Court addressed the question whether secondhand reports, used as the basis for an opinion under Rule 703, constitute hearsay. In its 2012 opinion, Williams, five justices had expressed their view that if the validity of an expert's opinion depends on the truth of the 703 statements, the statements are necessarily being put to a substantive hearsay use. Smith was a drug prosecution. The testing had been conducted pretrial and a report prepared by Elizabeth Rast. However, at trial the government called another laboratory analyst, Gregory Longoni, as the witness to testify about the identity of the drug. Longoni purported to offer an independent opinion but relied on Rast's statements and report. In an opinion authored by Justice Kagan, the Court stated that since the issue determined the scope of a federal constitutional right, the Court was not obliged to accept the State's "nonhearsay label." The Court reasoned that if a statement lends support to an expert opinion only if the statement is true, the statement is being put to a substantive hearsay use. In Justice Kagan's words, "truth is everything when it comes to this kind of basis testimony"; and such statements are "useful" to support the opinion only when they are true. While the opinion states that the statements were put to a hearsay use, the opinion adds that that use amounts to a Confrontation Clause violation only if the statement is "testimonial" under Crawford. The Court remanded to the lower court for a ruling as to whether Rast's statements and report were testimonial in nature.

Concurring in part in the opinion, Justice Thomas reiterated his view that statements qualify as "testimonial" only if they are relatively formalized with some solemnity. Also concurring in part, Justice Gorsuch lamented that the Court had not clarified the "primary purpose" test: Is the determinant the perspective of an objective observer, the perspective of the declarant, or the purpose for which the government intends to utilize the statement? Justice Alito wrote a separate opinion, joined by the Chief Justice, concurring only in the judgment. Justice Alito argued that the Court had inflicted a "wound on modern evidence law." He pointed out that if a judge admitted a statement only for the purpose of showing the basis of an opinion, the opponent would be entitled to a limiting instruction. The Justice surveyed the pertinent Supreme Court jurisprudence that, for the most part, assumes that lay jurors are capable of complying with limiting instructions.

4. The Witness's Application of the Methodology to the Case-Specific Facts

The International Organization for Standardization (ISO), the American Society for Testing and Materials (ASTM), the FBI's Technical Working Groups (TWGDAMs), the FBI's Scientific Working Groups (SWGDAMs), and the 23 subcommittees of the Organization for Scientific Area Committees (OSAC) in NIST

The prior tendency of some courts to treat questions relating to the application of the methodology as cutting only to weight rather than admissibility

The December 2023 amendment to Federal Rule of Evidence 702(d) intended to make it clear that the satisfaction of 702(d) is mandatory for the admission of the expert testimony

The evidentiary issues posed by the promulgated standards and protocols: the proponent's ability to overcome hearsay and authentication objections to the standards

Federal Rule of Evidence 801(a)

the limitation of the hearsay definition to assertive statements

the provisions in standards and protocols as strong or weak imperative sentences

Federal Rule of Evidence 902

- (5) official publications
- (6) periodicals
- (7) trade inscriptions
- 5. The Wording of the Expert's Final Opinion

Purported certainty

Daubert: "arguably there are no certainties in science"

the limited circumstances in which scientists use purely deductive reasoning

contrast scientific methodology in investigational science: It is always possible to conceive of another empirical test of the hypothesis. No matter how many tests the hypothesis has survived, there is always a possibility of subsequent falsification of the hypothesis. Therefore, in principle an hypothesis can never be deemed certainly, conclusively, or definitively validated.

The Advisory Committee Note to the December 2023 amendment to Rule 702—"absolute" or "100% certainty" and "a reasonable degree of scientific certainty"

The admissibility of opinions on mixed questions of law and fact

Federal Rule of Evidence 704

Article, The Admissibility of Expert Opinions Stating Legal Conclusions, 58 Crim.L.Bull. 683 (2022)

the split of authority

"ultimate issue" in 704(a), not "ultimate fact"

the general rule—Rule 702's mandate that the expert restrict his or her testimony to the limits of their expertise

expertise in science, not law

exceptional situations in which the legal standard incorporates an expert standard

statutes that make it a crime for a physician to prescribe drugs "without a legitimate medical purpose." "Medical purpose" is an expert standard, and an experienced physician's testimony can assist the jury resolve that issue.

Rule 704(b)'s restriction of expert opinions on state of mind

Diaz v. United States, 144 S.Ct. 1727, 219 L.Ed.2d 240 (2024) was a drug prosecution. The government alleged that the defendant knew that there were illegal drugs secreted in the automobile she was driving. At trial, the judge permitted a government agent to testify that "most" drug mules know that they are in possession of the drugs. The defense contended that the agent's testimony violated Rule 704(b). A 6-3 majority rejected the defense contention. Writing for the majority, Justice Thomas stated that Rule 704(b) excludes only a narrow set of opinions about the defendant's state of mind. The Justice stressed that the agent used the word "most," not "all." In the Justice's view, the agent had described a class of persons, drug mules, who may or may not have the verboten state of mind. In her concurring opinion, Justice Jackson pointed out that so limited, Rule 704(b) would frequently permit the defense to introduce exculpatory testimony.

In a dissent joined by Justices Sotomayor and Kagan, Justice Gorsuch argued that the agent's testimony clearly violated 704(b). In his judgment, an expert's testimony that a defendant "probably" had a certain mens rea would certainly violate 704(b). He saw no meaningful distinction between that testimony and the "most" language that the agent had used at trial.

6. Constitutional attacks on statutory and common-law restrictions on the admissibility of expert testimony

Article, *People v. Jackson* Upholding the Constitutional Right to Present Expert Testimony: Defining a "Weighty" Interest in the Plurality Opinion in *United States v. Scheffer,* 60 Crim.L.Bull. 48 (2024)

the leading Supreme Court precedents recognizing the right

the pre-Scheffer trend to extend the right to restrictions on expert opinion testimony

the plurality opinion in *United States v. Scheffer*, 523 U.S. 303 (1998)(the majority upholds a court-martial conviction after the military judge excluded exculpatory polygraphy evidence under Military Rule of Evidence 707 which purported to ban all polygraph testimony; the plurality opinion indicated that only a "weighty" interest can trump a restriction on defense evidence and that only a defendant's interest in presenting testimony based on personal knowledge can be "weighty")

the reference to "weighty" interests

post-Scheffer developments

the meaning of "weighty" interest

--testimony that the jury is likely to give great weight to and affect the outcome of the case

--testimony that the jury should give great weight to in order to enhance the reliability of factfinding

## II. RECENT DEVELOPMENTS IN SCIENCE—THE PRESENT AND THE FUTURE

A. Reforms in Laboratory Procedures

the research of Professor Itiel Dror describing the danger of the analyst's exposure to prejudicial, domain-irrelevant information

the development of Case Management (CM) procedures

The role of case manager

Linear sequential unmasking (LSU)

The dual importance of the existence of such procedures

If the laboratory does not have such procedures in place, the analyst may be exposed to prejudicial information that creates a subconscious bias.

If the laboratory has such procedures in place and the analyst violates the procedures, the violation may support an inference of the analyst's conscious bias.

- B. Specific Scientific Disciplines
  - 1. Artificial Intelligence (AI)

What if the proponent acknowledges that an expert used AI to create or alter the exhibit.

The limited use of the exhibit as illustrative evidence

New Federal Rule of Evidence 107

The use of AI to create an exhibit

A foundation for the scientific methodology under Daubert

The special problem posed by AI tools that have a significant degree of autonomy and are self-taught through unsupervised machine learning. Their operational rules may not be well understood even by the tool's developers. The opponent can argue that the proponent's showing does not satisfy

*Daubert* because the proponent's expert cannot describe the methodology in any meaningful detail. At the very least the methodology may be subject to a Rule 403 objection because it can be difficult to properly estimate the probative worth of the testimony.

The use of AI to alter the exhibit

An analogy to the foundation for the use of digital enhancement to modify a photograph

State of Washington v. Puloka, No. 21-1-04851-2 KNT, Findings of Fact and Conclusions of Law Re: *Frye* Hearing on Admissibility of Videos Enhanced by Artificial Intelligence (Super.Ct., King Cty. Mar. 28, 2024); Tim Stelloh, Washington State Judge Blocks Use of AI-Enhanced Video as Evidence in Possible First-of-Its-Kind Ruling, NBC News Digital (Apr. 2, 2024)

What if the proponent of the item of evidence does not acknowledge that the exhibit is the product of AI creation or enhancement?

The analogy to the treatment of allegedly assertive nonverbal conduct under the Advisory Committee Note to Federal Rule 801(a) (allocating the burden of proof to the opponent raising the hearsay objection)

2. Accident Reconstruction

The limitations of Event Data Recorders (EDR)-49 CFR Part 563

-----The failure to capture the entire collision event

Brach et al., Vehicle Accident Analysis and Reconstruction Methods 245 (3d ed. 2022). Exchanges of momentum between high-speed impacts usually last between 100 and 150 milliseconds. Some vehicles equipped with EDRs sold before 2012 cannot capture data for that amount of time. The CFR now requires that vehicles voluntarily equipped with EDR capture at least 250 milliseconds. A 2017 study found that the EDR did not capture the intersection entry in 13% of intersection crashes. Chen et al., N.H.T.S.A., Event Data Recorders Duration Study (2017). The typical five second recording duration did not capture pre-crash maneuvers in a significant number of cases.

-----Recording delays

The EDR must measure a certain change in acceleration before recording data. The EDR may not capture any data about pre-crash maneuvers. In one study, in 64% of the cases the EDR did not preserve any data about pre-crash steering maneuvers.

-----Clipping

There will be a loss of data if acceleration exceeds the range of data that the EDR is set to record. Part 563 requires accelerometers in EDRs to measure certain ranges of longitudinal acceleration (-50 g to +50 g). If the acceleration is below or above this range, the acceleration will not be recorded.

-----Multi-Event Collisions

The CFR describes a multi-event collision as one involving "the occurrence of two events, the first and last of which begin not more than five seconds apart." The EDR will overwrite data from previous events if the impact of a later event is larger than that of a previous event. Only one event may be fully recorded. Even the most advanced EDRs typically do not capture more than four or five events. When the information is extracted from the EDR, the result will be a report including a Data Limitations section; that section will indicate how many events the device is capable of recording.

-----Pedestrian Accidents

EDRs often fail to record pedestrian impacts. A pedestrian accident might not be of sufficient severity to trigger recording. Fugger, Efficacy of Event Data Recorders in Pedestrian-Related Accidents, in 7A Collision Reconstruction Methodologies: Event Data Recorder Interpretation (Armstrong ed. 2019). Most pedestrian impacts are not of sufficient severity to trigger the crash sensing algorithm and do not exceed the nondeployment threshold. There may be a 10x to 20x weight differential between the pedestrian and even a light vehicle.

-----Damaged EDR

The EDR itself might be damaged in the accident. The damage to the EDR can corrupt the recorded data. Fortunately, in most vehicles the EDR is not located in the area most vulnerable to collision damage. Thus, such cases are rare. The EDR ordinarily is not located in an area such as the front bumper which is easily vulnerable to damage.

-----Tampering

If the specific vehicle does not have a countermeasure such as a motor vehicle event data recorder connector lockout apparatus (MVEDRCLA), someone might access the data via the on-board diagnostics (OBD) port. Immediately after the collision, was the vehicle transported to a police impound yard or was it taken instead to the lot of a towing business?

#### -----Data Extraction

If the investigator does not use an appropriate tool to extract the data, the integrity of the data can be compromised. The tool must be suitable for that specific type of vehicle.

-----Data Interpretation

The analyst must consider where the EDR sensor was located. It is ideal if it was close to the specific seat, for example, the back seat for the injured passenger. This can be a major issue in T-bone or rear-end collisions which cause significant post-collision rotation.

In addition, in interpreting the data, the analyst must consider any modifications to the vehicle or deviations from the manufacturer's specifications. Did the car have a different size tire? Were the tires underinflated? Were the tires worn?

## 3. Blockchain

The challenge of identifying the persons or entities who control blockchain transactions. Liu et al., The Challenge of Bitcoin Pseudo-Anonymity to Computer Forensics, 52 Crim.L.Bull. 191 (2016); Meiklejohn et al., A Fistful of Bitcoins: Characterizing Payments among Men With No Names, in ICM '13 Proceedings: ACM Internet Measurement Conference 127 (2013). To send Bitcoin, the person or entity must control the address where the Bitcoin is stored. Each address has a public key with a corresponding private key. Thus, the Bitcoin stored at an address can be spent only by the holder of the private key.

---Identification Techniques Relying on Clustering (identifying addresses controlled by the same user)

(1) The Co-Spend or Multi-Input Heuristic

"If two (or more) public keys are used as inputs to the same transaction, then we say that they are controlled by the same user." Currency is stored at a certain address, secured by a combination of a public and private key. Sending money from an address therefore requires knowledge of the private key. Persons and entities generally do not share their private keys with other persons. Thus, if Bitcoin is sent from several addresses in a single transaction, there is an inference that *the same person or entity controls all the addresses that were inputs*. The analyst can therefore draw an attribution inference.

# (2) The Change Address Behavior Heuristic When a user sends Bitcoin from an address, all of the Bitcoin in that address must be sent. However, that amount may exceed what is needed, e.g., the purchase price. The difference is "sent back" to the original sender, typically at what is termed a new "change address." If

the change address is identified, it can be clustered with the original sender's address. *The same person or entity probably controls both the original address and the new address.* Again, the analyst can draw an attribution inference.

The investigator can then attempt to learn the ground truth about the identity of a person controlling one clustered address. The investigator usually obtains evidence directly attributing one address to a particular person or entity "off line." For example, the investigator could do so by: (a) directly contacting the address and perhaps transacting business with them; (b) going to collected lists of known or assumed addresses on fora or websites; or (c) contacting an involved money service business if under the Bank Secrecy Act it is required to have implemented know-your-customer (KYC) procedures, including a customer identification program (CIP), to gather enough information to form a reasonable belief that it knows the identity of its customers. Once the investigator determines the identity of a person controlling one address, the investigator can infer that the same person controls the other clustered addresses.

United States v. Sterlingov, 719 F.Supp.3d 65 (D.D.C. 2024)

--Confounding Factors That Can Obfuscate Cryptocurrency Transactions

(1) Mixers. A mixer service takes a user's coins and returns coins that have no connection to the ones that were sent. Mixers "make the deposited funds more difficult to track by letting users schedule their withdrawals in randomized amounts at randomized intervals."

(2) CoinJoin. This technique relies on the principle of plausible deniability. In a CoinJoin transaction, inputs by multiple users are put into a single transaction. Each intended recipient receives the amount they are owed, but it could originate from any person or combination of people in the CoinJoin pool. There is no way of knowing which party in a transaction sent funds to which recipient.

4. Body Fluid Analysis

Proteomic Mass Spectrometry. The identification of the type of fluid found at a crime scene can be an important clue to the nature of the crime. Blood suggests one type of crime while semen points to another kind of offense. In the past, laboratories have used a variety of tests to classify body fluids. The preliminary tests include Kastle-Meyer, Phadebas, urea, and seratic. However, these non-specific tests usually test for only one type of fluid and are prone to false positives. RNA can be used as a confirmatory test, but proteins are more stable than RNA. In addition, the RNA methodology requires amplification which can introduce contaminants. The human proteome was mapped in 2014. The Office of the Chief Medical Examiner for New York City has developed a proteomic mass spectrometry methodology as a better specific, confirmatory test. Siegel, Proteomic Body Fluid Assay Validation, Molecular Serology Validation 1 (Apr. 2023), https://www.nyc.gov/assets/ocme/downloads/pdf/molecular\_serology\_validation.pdf; Forensic Tech. Ctr. of Excellence, Implementation Strategies: Proteomic Mass Spectrometry for Biology Fluid Identification 2-3 (Feb. 2021), https:forensiccoe.org/private/603e86dfaf686; Butler et al., The Development and Validation of Multiple Reaction Monitoring (MRM) Mass Spectrometry (MS) Assay for Confident Identification of Protein Biomarkers for Blood, Semen and Saliva, Am. Acad. Forensic Sci. (2021), https://www.aafs.org/sites/default/files.medica/documents/AAFS-2021-B6.pdf; Yang et al., Body Fluid Identification by Mass Spectrometry, 127 Int'l J. Legal Med. 1065 (2013). The assay employs HPLC-MS/MS (high performance liquid chromatography/tandem mass spectrometry.)

----The starting point is the collection of a sample at the scene perhaps collected on a cotton swab. The sample could be blood, semen, saliva, or sweat.

-----Different fluids have different sets of marker proteins. Different fluids perform different functions, and proteins regulate functions. The marker proteins for blood are HBB, HBA, and SLC4A1. In contrast, the marker proteins for saliva are AMY1A, CST2, HTN1, and LEG1H. Those for semen are SEMG2, SEMG1, and KLK3.

----The laboratory uses trypsin to break the proteins down into peptide sequences. The OCME uses nine peptide markers to identify blood, eight for saliva, and seven for semen. For example, the marker protein HBB for blood breaks down into the marker peptides SAVTALWGK, VNVDEVGGEALGR, and LLVVYPWTQR. The marker protein HBA for blood breaks down into VGAHAGEYGAELER, TYFPHFDLSHGSQQVK, and FLASVSTVLTSK. Finally, the marker protein SLC4A1 for blood breaks down into IPPDSEATLVLVGR, ADFLEQPPVGFVR, and ASTPGAAAQIQEVK. The presence of those nine peptide markers would establish the presence of those three marker proteins.

---The laboratory then subjects the sample to MS and relies on four ion fragments to identify each peptide marker. The x-axis of the spectrum shows the mass of each ion while the y-axis shows its intensity.

This technique is very promising. The OCME has conducted validation studies, and the assay has been approved by both the ANSI National Accreditation Board and the New York State Commission on Forensic Science. However, at this point there is limited data. The initial OCME study involved only 20 donors for blood, 24 for saliva, and 27 for semen. Of course, given the sample size, the demograhics of the current data base do not include persons of all ages and ethnicities. It has not been demonstrated that the methodology can be reliably applied to persons falling outside the parameters of the data base. However, as we shall see, proteomics is an emerging field, and the use of proteomic mass spectrometry for fluid classification may make its advent in court in the near future.

5. DNA Analysis

As the years have passed, the sensitivity of DNA testing has improved dramatically. DNA testing methodologies can now detect and identify much smaller quantities of DNA. Expressions such as "contact," "touch," or "trace" DNA refer to minute, detectable quantities of DNA. However, the increased sensitivity of DNA testing can be a two-edged sword for the prosecution. It is not only easier to detect DNA; common sense suggests that smaller DNA quantities can also travel and be transferred. For that reason, there has been a shift from attribution/source defenses to activity defenses.

The Amanda Knox case in Italy. The police found the DNA of Knox's boyfriend on the victim's bra clasp and a knife that was allegedly used to kill the victim.

The Lukis Anderson case in California. The laboratory found the defendant's DNA on the victim's finger. However, the same medics who reported to the crime scene had treated Mr. Anderson only hours before. They had placed a fingertip pulse oximeter on his finger—the same oximeter they later placed on the finger of the victim.

The Bryan Kohberger case in Idaho

These cases have given birth to the DNA transfer defense. Suppose that a defendant's DNA is found at the crime scene. On the one hand, the defense might not deny that the DNA is the defendant's. On the other hand, the defense can focus on the manner in which the DNA came to be at the scene. The defense might contend that the presence is not due to a primary transfer from the defendant's criminal activity at the scene in which the defendant came into direct contact with the person or object his or her DNA was found on. Rather, the defense might argue that the explanation for the DNA's presence is an indirect mechanism, namely, a prior secondary or tertiary transfer. Sessa et al., Indirect DNA Transfer and Forensic Implications: A Literature Review, 14 Genes 2153 (2023).

It is certainly plausible that a small quantity of DNA could be transferred from one person to another person or object and so on. Even without the benefit of expert testimony, in opening statement and throughout the trial the defense might suggest a secondary or tertiary transfer as the innocent explanation for the presence of the defendant's DNA at the scene. The question for prosecutors has become whether they can marshal expert testimony to rebut the suggestion. The need for rebuttal evidence is one of the reasons for the emergence of DNA Transfer Probability Analysis (DTPA). The purpose of the analysis is to estimate the likelihood that DNA could be present at a scene as a result of a primary, secondary, or tertiary transfer.

---The initial step is attempting to estimate the range of DNA that could be present by virtue of one of these types of transfer. The analyst employs qPCR, quantitative real-time polymerase chain reaction in order to do so. Ultimately, the analyst will compare the DNA quantity found in the instant case to a range of quantities that under similar circumstances, one would expect to find due to a primary, secondary, or tertiary transfer. To estimate that range, the expert might rely on: (a) published studies; (b) his or her experience; or (c) an experiment attempting to duplicate the conditions in the instant case. Texas Forensic Science Commission, Final Report on Complaint No. 23.67: Tiffany Roy; (Timothy Kalafut, Ph.D.; Evaluation of Biological/DNA Results Given Activity Legal Propositions) 43-40 (July 26, 2024).

Suppose that the analyst chooses option (c). Under circumstances similar to those in the instant case, the analyst simulates multiple primary, then secondary, and finally tertiary transfers. For each set of simulations, the analyst computes a mean and standard deviation of the DNA quantity as indicated by fluorescence—the expected range for a primary transfer, then a secondary transfer, and finally a tertiary transfer.

---The analyst then compares those ranges to the quantity found in the instant case.

---In Europe, it is common to conduct the comparison by constructing a likelihood ratio. Biedermann et al., Evaluation of Forensic DNA Traces When Propositions of Interest Relate to Activities: Analysis and Discussion of Recurrent Concerns, 7 Frontiers Genetic 215; Gill et al., DNA Commission of the International Society for Forensic Genetics: Assessing the Value of Forensic Biological Evidence—Guidelines Highlighting the Importance of Propositions. Part II: Evaluation of Biological Traces Considering Activity Level Propositions, 44 Forensic Sci. Int'l: Genetics 102186, 10. The numerator and denominator in the ratio are competing hypotheses. In one case, the numerator might be that the DNA quantity is due to a primary transfer. What is the probability that the defendant would have left this DNA quantity as the result of a primary transfer? The denominator could be that the quantity is due to a secondary or tertiary transfer. What is the probability that the defendant would have left this quantity as the result of a secondary (or tertiary) transfer? The ratio indicates how many times more likely it is that the transfer is a primary one rather than a secondary or tertiary transfer.

---The ratio is sometimes expressed on a verbal scale:

Limited support (LR = 2-10)

Moderate support (LR = 10-100)

Substantial support (LR = 100-1,000) Strong support (LR = 1,000-10,000) Very strong support (LR = 10,000-1,000,000) Extremely strong support (LR > 1,000,000).

This type of analysis poses two significant problems. First, the analyst is trying to compare the DNA quantity found at the scene with the range that would be expected in the case of a primary, secondary, or tertiary transfer under similar circumstances. In some cases, the defense might go the length of suggesting the circumstances leading to a secondary or tertiary transfer. The accused might suggest that a day before the stabbing, he met with and shook hands with a third party whom the defense claims actually committed the stabbing. The expert would then investigate the question of the quantity of the defendant's DNA that one would expect to be transferred from the killer's hand to the knife handle. Even in this situation, it might be difficult to identify and estimate the impact of all the factors that could affect the amount of the defendant's DNA eventually deposited on the knife handle. The factors could include:

--the defendant's shedding status (Jansson et al., Assessing the Consistency of Shredder Status Under Various Experimental Conditions, 69 Forensic Sci. Int'l: Genetics 1);

---environmental factors such as the temperature, UV light, and humidity;

---the nature of the surface if the defendant touched a surface and the perpetrator picked up the defendant's DNA by touching the same surface (Ramsey, Persistence of Touch DNA for Forensic Analysis, 2023 Nat'l Instit.Just. 1 (steel versus cotton)); and

---the amount of time between the primary and later transfers.

Since the popularity of activity defenses is a relatively new development, it is to be expected that there has been only limited research into the effect that these factors can have on the DNA quantity.

Second, it may be very difficult for the expert to identify the parameters that have to be duplicated to conduct tests "under similar circumstances." If the defense suggests only the vague possibility of a later transfer, it is almost impossible for the expert to specify the parameters. On the one hand, in this situation the prosecution can dismiss the defense suggestion as "mere speculation." It is even conceivable that a judge might bar the suggestion under Federal Rule of Evidence 403, but the defense might challenge that ruling as a violation of the accused's constitutional rights to present a defense and attempt to raise reasonable doubt. On the other hand, if the judge permits the defense suggestion, it will be difficult for the prosecution to marshal expert testimony to rebut the suggestion.

At this point, given the limited available data, this type of expert rebuttal testimony may not pass muster under *Daubert*. When surveyed, most participating American DNA analysts stated that given their courtroom experience, they anticipated difficulty if an attorney attempted to elicit their testimony about DTPA. Prinz et al., Global Survey on Evaluative Reporting on DNA Evidence with Regard to Activity-Level Propositions, 69 J. Forensic Sci. 978, 810 (2024). Today, "only a few laboratories around the world . . . issue reports on the probability of seeing a DNA result under two competing" hypotheses. Id. at 812. In the long term, though, given the benefit of additional research data, judges might admit such testimony under carefully circumscribed circumstances such as when the specific facts of the case enable the expert to conduct a DTPA analysis in strikingly similar circumstances.

6. Drug Testing

## GC/MS

Sotelo et al., The Myth of Gas Chromatography/Mass Spectrometry (GC/MS) in the Singular, 59 Crim.L. Bull. 339 (2023). Do not accept the conclusory statement that the laboratory used "GC/MS" to specifically confirm the drug's identity. The term "GC/MS" encompasses a large number of combinations of hardware, software, and procedures, and some combinations are not suitable for particular types of drugs.

## -- The GC Separation Phase

Did they use an old injection port septum? Septa have a limited useful life. "If the septum is worn or leaking, its condition will reduce the sensitivity of the test."

At what temperature did they set the injection port? "If the temperature is set too low, the analyte will not be completely evaporated. In that event, the separation will be poor . . . . If the temperature is set too high, the excessive heat can cause unnecessary decomposition of the sample, change its structure, and even cause unwanted, misleading peaks on the final spectrum."

What method of injection did they use? Direct injection is "normally reserved for compounds that are thermally unstable, low volatility, or reactive analytes." The other possibilities are splitless injection and split injection.

--The MS Injection Phase

What method of ionization did they use? One possibility is electron ionization (EI). However, "EI tends to produce more complex spectra than chemical ionization (CI). The complexity of the spectra increases the probability of error if the analyst ultimately decides to manually prepare an interpretation of the final spectrum." Another possibility is CI. However, negative "CI is not suitable for all compounds; it is used mainly for compounds with high electron affinity."

What type of analyzer did they use to evaluate the ions? One possibility Is a simultaneous ion transmission analyzer. Another choice is a scanning analyzer. However, they have limited sensitivity. The analyst decides the setting on the instrument. "If the analyst chooses a wide range such as m/z 30-550 but the ions are of low molecular weight . . ., the analyzer might produce fewer or less intense peaks in a given mass spectrum."

Even if the analyst selected an appropriate combination of equipment, the final mass spectrum must be interpreted; the spectrum is not self-explanatory. Gin et al., Gas Chromatography-Mass Spectrometry Technique: In Scientific Evidence, Even "Gold Standard" Techniques Require Close Scrutiny, 56 Crim.L.Bull. 109 (2020); 2 Giannelli et al., Scientific Evidence § 23.03[4][c] (6<sup>th</sup> ed. 2020).

There are different modes of scanning (id. at [4][c][ii])

Full Scan

Selective Ion Reliance

Selective Ion Monitoring—the hypothesis that a certain combination of ions is sufficiently specific to identify the drug

In addition, there are different methods of evaluating the spectrum (id. at § [4][c][i])

## Manual analysis

The analyst assigns mass numbers to each peak, identifies the tallest or base peak and assigns it an intensity of 100%, identifies the parent peak with the highest mass number (all the fragments must fit into the molecular weight indicated by the parent peak), and assigns numbers to all the peaks. Analyzing the spectrum is like putting together a jigsaw puzzle; the analyst must account for every peak with 3% or greater intensity. Given this process, there can be numerous pitfalls:

--The analyst might not have all the puzzle pieces. If the GC did not achieve full separation, peaks could overlap.

--The analyst might have the wrong pieces. If the instrument does not automatically mark the horizontal axis, the analyst might assign the wrong mass unit number to a peak.

--The analyst might be unable to fit every puzzle piece into the proposed solution.

--The analyst might choose the wrong parent peak. The last peak is not necessarily the parent peak. An isotope of the chemical might be present.

Computerized analysis

The computer compares the spectrum of the unknown to a spectral library. NIST has prepared a widely used library. However, NIST periodically revises the library and replaces older images with higher resolution images.

If the software yields a candidate list, the final selection must be made by a human expert.

#### LC/MS-MS

Snkhchyan et al., A New "Gold Standard": LC/MS-MS Analysis in Driving Under the Influence of Cannabinoid Cases, 57 Crim.L.Bull. 245 (2021). The use of LC/MS-MS

eliminates the need for complicated derivatization processes which traditional GC/MS testing requires before introducing the sample into the instrument for analysis. Derivatization is an essential step in GC-MS analysis. Derivatization chemically changes compounds to produce properties that are better suited for testing using traditional GC-MS instrumentation. Derivatization creates a distinct problem for cannabinoid analysis because studies have shown that the process . . . causes an artificial inflation of . . . Carboxy-THC concentration, a metabolite of . . . THC. Some studies report up to a two-fold increase in Carboxy-THC concentrations as a result of derivatization in GC-MS methods. Id. at 254-55.

7. Fingerprint Examination

Haselton-Parke et al., The Perception of Fingerprint Examination, 59 Crim.L.Bull. 115 (2023)

At one time before the advent of DNA typing, fingerprint examination was regarded as "the gold standard" of forensic evidence. Many trial judges permitted examiners to testify explicitly that the methodology has "a zero error rate." However, both a 2011 Scottish report and a 2012 report by the American National Institute of Standards and Technology condemned the use of such absolutist language.

The courts have also begun to forbid such language. United States v. Llera Plaza, 188 F.Supp.3d 549 (E.D.Pa. 2002). In part, they have done so because of mounting evidence of the error rate in forensic analysis. In a 2021 study by Professor Jonathan Koehler and Shinquan Liu, examiners were asked to study two pairs of close non-matches. Fingerprint Error Rates on Close Non-matches, 66 J. Forensic Sci. 129 (2021). They reported a 15.9% error rate.

In a 2011 study, Busey et al., Consistency and Variability Among Latent Print Examiners as Revealed by Eye-Tracking Methodologies, 61 J. Forensic Identification 60 (2011), the researchers studied interexaminer variation. The researchers focused on the participants' eye movements. The researchers found that even when different participants reached the same conclusion, their eye movements indicated that they were relying on different parts of the fingermark—and often disregarding parts that another examiner thought to be significant. A 2014 study reached a similar conclusion. Ulery et al., Measuring What Latent Fingerprint Examiners Consider Sufficient Information for Individualization Determinations, 9 PLoS ONE 1 (2014).

There have also been studies of intraexaminer variability. In one, Dror and Charlton gave five examiners a pair of fingerprints from one of their previous cases. Starr, the Bias Hunter, 376 Sci. 686 (2022). They did not inform the examiners that they had previously examined the same prints. Rather, they told the examiners that the prints were from the notorious case of Brandon Mayfield. The majority of the examiners reached a conclusion contrary to the conclusion they reached when they previously examined the prints. In a similar study, the examiners' exposure to prejudicial, domain-irrelevant information prompted 17% of the conclusions to change. Spinney, The Fine Print, 464 Nature 344 (2020).

Even when the examiner has not been exposed to potentially biasing information, perceptual problems can lead to an erroneous conclusion. Many laboratories do not require their fingerprint examiners to be tested regularly for perceptual conditions such as Diabetic Macular Edema (DME). Moreover, a person can gradually develop cataracts, and the person may not realize that the degenerative process has begun. Alternatively, suppose that the examiner does not have a diagnosable defect in perceptual faculty. At the time they conduct the analysis, they may be suffering from temporary visual fatigue. When an examiner is searching for identifying minutiae, their eyes are constantly going back and forth between the known mark and the unknowns. There is a risk when an examiner begins the analysis of a difficult set of prints at the end of a business day. When the examiner is fatigued, the examiner is susceptible to a number of issues.

---Pareidolia. In the words of The Fingerprint Sourcebook released by NIST in 2022, "[p]eople engage in a variety of processes that organize and impose structure on information as it comes in from the external world." When the object being studied is ambiguous and displays complex features, there is a natural tendency to project and impose structure even when none exists. If an examiner believes that he or she has "perceived" a pattern in the known, they might be tempted to interpret the features of the unknown in favor of finding the same pattern.

---The Muller-Lyer Illusion. The illusion is an example of the difficulty that an observer can encounter in determining whether two lines are of the same length—a sort of determination that the examiner makes in virtually every comparison. Suppose that two lines are of the same length. If one has arrows at the end pointing away from the line but the other has arrows pointing toward the line, many persons mistakenly conclude that the lines are of different length. Smudging near the end of lines in fingermarks can produce the same mistake.

---The Shepard's Tabletop Illusion. The essence of this illustration is that when two identical parallelograms are positioned at 45 degree angles away from each other, the person's processing of the perceptual information can lead them to erroneously conclude that the two shapes differ.

These findings have led to a number of recommendations. To begin with, laboratories should ensure that their examiners have regular eve examinations. If the expert's laboratory does not follow that practice, that subject can be explored during cross-examination. In addition, they should have regular training in the prevention of mistakes such as the Muller-Lyer illusion. Furthermore, laboratories should require that examiners annotate and mark up the fingermarks during the initial examination of each latent and exemplar. NIST has released ACEware, a software program that facilitates the markup. The markup can help the examiner remember during the examination of an unknown that only a few minutes before he or she had dismissed a detail in the known as inconsequential. Finally, courts should consider giving cautionary instructions about fingerprint examination similar to the instructions about the weaknesses in eyewitness identification. Commonwealth v. Gomes, 470 Mass. 352, 22 N.E.2d 897 (2015), modified by Commonwealth v. Bastaldo, 472 Mass. 16, 32 N.E.3d 873 (2015). After all, like lay

witnesses to crimes, expert witnesses conducting fingerprint examiners can fall prey to perceptual weaknesses.

#### 8. Intoxication Testing

The shift to more specific portable devices to be used roadside

In the past in many jurisdictions, the practice was to administer a relatively nonspecific field test such as a passive alcohol sensor (PAS) to the accused and, if that test was positive, later transport the accused to a police facility for a more specific test such as an intoxilyzer relying on infrared technology. However, manufacturers are beginning to market smaller, portable versions of more specific instruments for roadside use. This development raises two issues: (1) The empirical validation of the more traditional, larger, laboratory version of the instrument does not necessarily support the inference that the new smaller version is reliable; and (2) the officer's credentials to conduct the earlier nonspecific test may not qualify him or her to use the new version of the more sophisticated test. Thus, the defense might argue that: (1) There has been an inadequate showing of the validation of the novel, smaller version of the instrument to satisfy Daubert; and/or (2) even if the officer was qualified to administer a PAS field test, there has been an insufficient showing of the officer's training to use the more sophisticated instrument roadside.

Testimony about confidence intervals

Vosk & Emery, Forensic Metrology: Scientific Measurement and Inference for Lawyers, Judges, and Criminalists (2014); Vosk et al., Measurements in Forensic Science—Of Errors and Uncertainty, 53 Crim.L.Bull. 532 (2017); Land et al., Confidence Intervals: How Much Confidence Should the Courts Have in Testimony About a Sample Statistic?, 44 Crim.L.Bull. 257 (2008).

The fundamental tenet of metrology: No matter how carefully the measurement is conducted and no matter how well maintained the calibrating instrument, one can never be certain that the measurement captures the true value of the measurand.

The meaning of a confidence interval

NOT that this interval certainly captures the true value.

NOT a probability that this interval captures the true value.

The probability that in the long term, a certain percentage of the intervals computed in the same fashion would capture the true value.

The argument that whenever the proponent presents an expert's estimate, the estimate should be accompanied by a confidence interval.

The International Organization for Standardization: "Knowledge of the uncertainty associated with measurement results is essential to the interpretation of the results."

The National Research Council Report, Strengthening Forensic Science in the United States: A Path Forward 167 (2009): "All results for every forensic science method [should] indicate the uncertainty in the measurements that are made."

The 2011 English Law Revision Commission

The case law

Washington v. Weimer, No. 7036A-09, slip op. (Snohomish Cty., Dist. Ct., Wash. Mar, 23, 2010)

Washington v. Fausto, No. C076969 & No. 9Y6231062 (King Cty., Dist. Ct., Wash. Sept. 21, 2010)

State v. King County District Court West Div., 175 Wash.App. 630, 307 P.3d 765 (2013)

Federal Rule of Evidence 402

a ban on the enforcement of uncodified categorical exclusionary rules (such as the Frye general acceptance test) and on the announcement of new uncodified categorical rules

Federal Rule of Evidence 403

Ad hoc, case-specific balancing vs. the enunciation of categorical rules

What if the measured BAC is marginal (barely in excess of the per se limit) and the confidence interval is wide? That combination of factors presents an acute risk that the jury will overvalue the measurement and that the overvaluation will cause a wrongful conviction.

Drug Recognition Expert (DRE) testimony

Mills et al., Testimony by Drug Recognition Experts: A Critical Review of the State of the Empirical Research, \_\_Crim.L.Bull.\_\_ (2024)

The 12-Step DRE Protocol

- 1. The administration of a breath alcohol test to rule out alcohol as a cause of the signs the arrestee is exhibiting.
- 2. An interview of the arresting officer. The DRE inquires about the arrestee's driving conduct and asks whether the arresting officer found drugs, empty pill bottles, or drug paraphernalia.
- 3. A preliminary examination of the arrestee, including a first pulse check.
- 4. An eye examination, notably for HGN. At steps #4 and 7, the DRE checks for ocular side effects of drug use, such as lack of convergence, that could be a manifestation of impaired neurological functioning. The HGN test itself has three components: (a) lack of smooth pursuit—the eyes jerk or "bounce" as they try to follow a smoothly moving stimulus such as a pencil, penlight, or finger; (b) distinct, sustained nystagmus at maximum deviation—sustained jerking is evident when the eye is held at maximum deviation for a minimum of four seconds and continues to jerk toward the side; and (c) onset of nystagmus prior to 45 degrees.
- A divided attention/field sobriety test. The protocol incorporates some of the Standardized Field Sobriety Tests (SFSTs) which in part gauge a person's capacity to perform divided attention tasks.
- 6. An examination of vital signs, including a second pulse check.
- 7. A darkroom examination. This step continues the eye examination begun in step #4. The DRE studies the arrestee's eyes under three lighting conditions.
- A physical examination for muscle tone. The DRE might feel the arrestee's arm and other parts of their body. The tone is likely to be flaccid if the arrestee has ingested a central nervous system (CSN) depressant but rigid if they have consumed a stimulant, hallucinogen, or dissociative anesthetic.
- 9. A check to determine whether the arrestee's body exhibits an injection site or track marks together with a third pulse check.
- 10. An interview of the arrestee in compliance with *Miranda*.
- 11. The DRE's formation of his or her opinions. At this point, the DRE consults the Drug Symptomatology Matrix.
- 12. Subsequent toxicological examination to detect the presence and level of various drugs.

The Various Inferences the DRE May Attempt to Testify to

- 1. The person's external signs were not caused by alcohol consumption. This opinion seems defensible if it is based on a negative intoxilyzer result.
- 2. The person's external signs were not caused by a medical condition. This is an opinion on medical etiology. In State v. Brightful, 2012 Md.Cir.Ct.LEXIS 1, 10 (Mar. 5, 2012), the court ruled that without additional training, a DRE officer is unqualified to render an opinion on this subject. However, another court might allow the officer to testify that the defendant did not display any of the telltale signs of medical conditions that could cause the defendant's external signs.
- 3. The arrestee's external signs were caused by some unidentified drug. In the *Olenowski* case, *infra*, Master Lisa acknowledged that there are conflicting studies on this issue; but in his mind the more persuasive studies indicated that an officer may form this very generalized opinion.
- 4. The arrestee's external signs were caused by a substance in a particular category of drugs. The DRE uses a Drug Symptomatology Matrix with several categories: CNS depressants, CNS stimulants, hallucinogens, dissociative anesthetics, narcotic analgesics, inhalants, and cannabis. The matrix relies on the normal effects of the various categories. The matrix was first developed in 1987. The matrix is a toxidrome recognition tool. Although the DRE officer is a layperson, there has been substantial medical input to the matrix's development. In *Olenowsk*i, several medical witnesses testified that the matrix's classification scheme is similar to that in leading medical texts such as GOLDFRANK'S and that the use of matrix is consistent with clinical practice.
- The arrestee's external signs were caused by ingestion of a specific drug. In dictum in State v. Bealor, 187 N.J. 574, 902 A.2d 226 (2006), the court stated that an officer could opine that the external signs were caused by ingestion of marijuana. *Brightful* took a contrary position.
- The person had a certain level of drug in his or her system. In State v. Baity, 991 P.2d 1151, 1160 (Wash. 2000), the court held that a DRE officer "may not predict the specific level of drugs present in a system."
- 7. Given the external signs, the average person would have been impaired. If the court accepts the matrix as reliable, the matrix can serve as a basis for this opinion.
- This specific person was impaired at the time of the administration of the DRE protocol. There is a lack of empirical data establishing a correlation between levels of a drug in a person's system and clinical symptoms of impairment.

9. This specific person was impaired at the time of his or her operation of their motor vehicle. There is considerable evidence that in most cases, after consuming a certain amount of alcohol, the level in the person's system rises at a certain rate and then declines at a predictable rate. The state of the research into drugged driving cases does not support a similar generalization.

In State v. Daly, 775 N.W.2d 47, 58-59 (Neb. 2009), the court declared that "every court to have considered the issues has concluded that testimony based upon DRE protocol is admissible into evidence." In early 2024, a Pennsylvania court stated that "Pennsylvania courts have generally agreed with federal courts that a witness with the requisite observations and experience may offer a lay opinion to establish DUI-controlled substance impairment." Commonwealth v. Nestor, 2024 Pa.Super.LEXIS 130 (Super.Ct. Apr. 10, 2024). However, in 2022, the Michigan Court of Appeals held that the methodology does not pass muster under Daubert. People v. Bowden, 344 Mich.App. 171, 999 N.W.2d 80 (Mich.Ct.App. 2022).

The lengthiest discussion appears in State v. Olenowski, 255 N.J. 529, 304 A.3d 598 (2023). In dissent, Justice Pierre-Louis stated that DRE testimony should be barred. The thrust of his argument was twofold: (a) the error rate factor is the most important consideration in determining the reliability of DRE testimony; and (b) the government failed to present "meaningful" error rate data. He emphasized some of the data in a 2017-18 retrospective New Jersey DRE study. The public defender pointed out that in that study, "78.1% of those who tested negative for drugs were nonetheless identified as drug positive through the DRE protocol." The justice asserted that in his view, if the false positive rate was "in fact" that high, the methodology certainly does not satisfy *Daubert*.

In response to the dissent's second criticism, the majority stated that there could be numerous explanations for a subsequent negative toxicology report, including "delays in obtaining a warrant; time otherwise consumed in getting a sample without a warrant; lab testing cutoffs; [and] the non-testability of NPS (novel psychoactive substances) and polydrug combinations . . . ." The majority also noted the false negative data in the New Jersey study; after considering the data, expert witnesses had testified that in "82.5% to 92.6% of the cases" in which the person had consumed a drug, subsequent toxicological analysis confirmed drug consumption. The majority acknowledged that it was possible to attain "a high sensitivity rate . . . by assuming that all

drivers who were subjected to the protocol are drug impaired," but the majority agreed with Master Lisa's conclusion that "DREs are excellent at identifying true positive cases."

With respect to the dissent's first criticism, the majority rejected the position that error rate data should be "categorically" the most important. The majority noted that in *Daubert*, the Supreme Court had stressed that the test is "flexible." The majority then pointed to the extensive testimony about the standardization of the protocol, the number of published studies, including several peer reviewed studies, and the persuasive evidence of the general acceptance of the methodology. In light of that testimony, the majority ruled that the DRE methodology is sufficiently reliable.

However, the majority then imposed several limitations on DRE testimony.

---The majority announced that "a DRE is only allowed to opine in court that the protocol has presented indicia that are 'consistent with' the driver's usage of certain categories of drugs. The DRE's expert opinion testimony must not go further than that." More specifically, in his or her expert capacity, the DRE may not testify that "a driver is actually impaired" or that "the drug categories identified by the DRE are definitively the cause of any such impairment."

---The toxicology report mentioned in Step 12 is so important that if the DRE officer does not make "a reasonable attempt to obtain a toxicology report when it is feasible to do so," the DRE testimony is inadmissible.

---The defense is entitled to an opportunity to impeach and rebut the government's DRE testimony.

#### 9. Microbial Analysis

Steussy et al., Microbial Forensics: The Biggest Thing Since DNA?, 51 Crim.L.Bull. 726 (2015)

The microbial cloud and the human microbiome

Phylogenetic analysis to isolate microbes and identify their DNA sequence

The potential courtroom uses of microbial analysis

---personal identification

Magni, Procopio & Gino, You Leave a "Microbe Fingerprint" on Every Piece of Clothing You Wear and It Could Help Forensic Scientists Solve Crimes, <u>https://phys.org/news/2024-05-microbe-fingerprint-</u> <u>piece-forensic</u> (May 25, 2024)("another thing very specific to an individual is the unique community of microorganisms on and within their body"; in one study, two individuals wore cotton T-shirts for 24 hours; the shirts were tested six months later; "[r]esults showed that the two volunteers transferred distinct and recognizable microbes onto the clothing, each unique to the respective individual"); The 2010 Fierer study attempting to identify

computer keyboard users (51 Crim.L.Bull. at 746);

---soil mapping through the preparation of biogeographical maps

The 2011 Griffiths study (id. at 748-49)

---the identification of the type of body fluid

The 2012 Giampaolo experiment (id. at 747)

---estimating the postmortem interval (time of death)

The 2013 Metcalf study (id. at 744-45)

Bateman et al., The Use of "the Microbial Community Clock Methodology" to Estimate Time of Death, 57 Crim.L.Bull. 599 (2021)

This article focuses on one of the promising uses of microbial analysis, estimating time of death. The article begins by noting that the courts are fully aware of the uncertainties that attend both the traditional methods of estimating TOD (algor, rigor, and livor mortis) and even the more modern forensic entomology techniques.

The article then describes an alternative microbial technique. The basic theory underlying the technique is that as time progresses

after death, the types of microbes present and their relative abundances change. There are at least three stages: when the body is fresh, the advanced decay stage of the decomposition process, and the period after the body becomes dry. Id. at 604. More specifically, for a given area and season the researcher follows these steps:

--finding samples, namely cadavers;

--storing the samples prior to the extraction of the microbial DNA; --PCR amplification of the DNA;

--sequencing. The DNA is run through a high-throughput sequencer. The sequencer determines the DNA sequence, the order in which the ACGT bases appear in the sample. That sequence identifies which specific types of microbes—which taxa—are present.

--determining the abundance of each type of microbe and the ratio between among the various types of microbes.

After completing these steps in the "sequencing pipeline," the analyst can compare the data to the data in the instant case. That comparison could yield an estimate of TOD. In some studies, researchers found that the methodology enabled them to accurately estimate TOD "within 3.30+/-2.52 days." Id. at 605.

Although this technique is promising in the long term, in the short term there are serious questions about the reliability of any estimate based on the microbial clock:

--The database of samples is not representative. The majority of the decedents in the published studies are elderly Caucasians. There is little research with respect to other age or racial groups. --In most of the published studies, the sample size is relatively small.

--There is no standardized protocol for sampling. Researchers use swabs to collect samples. However, the pressure and force of the site's contact with the swab can vary. Moreover, there is no standard dictating how many seconds the investigator should apply the swab—15, 30?

--There has been little research into the effect that longer storage periods such as weeks or a month can have on the result.

--The laboratory uses primers during PCR amplification. The selection of different 16S primers can result in varying detection or differentiation of microbes.

--There are different techniques for collecting the information about the abundance of the microbes present. "In a recent study by Kaszubinski and colleagues, the researchers compared three widely used bioinformatic pipelines (MG-RAST, mothur, and QIIME2). In each case, they used the same input sequence data, namely, the data from [a] 2018 Pechal study (n = 188). The researchers found significant differences across the three pipelines. The different pipelines yielded different findings as to the relative abundance of bacterial taxa . . . ." The bottom line is that "'[i]ncreased standardization of the steps in the 'sequencing pipeline' is probably necessary before the proponent of the microbial clock methodology" can establish the admissibility of TOD estimates based on this technique.

#### 10. Pathology

Shaken Baby Syndrome (SBS)

2 Giannelli et al., Scientific Evidence § 19.05[2][[b][ii][B] (2023 Supp.); Article, Shaken Baby Syndrome: A Genuine Battle of the Scientific (and Non-Scientific) Experts, 46 Crim.L.Bull. 156 (2010).

> The difference of opinion between pediatricians and pathologists, on one side, and biomechanical experts on the other

> > The former group points to cases in which there was evidence of shaking but not of striking. (However, a traumatized caregiver might have repressed the memory of striking, and a murderer might lie about the striking.)

> > The latter group points to studies involving anthropomorphic models and primates. (However, medical ethics prohibited experiments with human infants.)

Smith v. State, 315 Ga. 287, 882 S.E.2d 300 (2022). In part on the basis of the SBS testimony, the defendant had been convicted of murder and aggravated battery in the 2002 death of his infant son. Twenty years later the defense filed an extraordinary motion for a new trial on the ground that in the intervening two decades, research had undermined the reliability of the SBS theory. The court ruled that such testimony would constitute newly discovered evidence justifying a new trial.

State v. Nieves, 476 N.J.Super. 609, 302 A.3d 595 (Super.Ct. 2023). For the purposes of determining whether the SBS qualifies under *Frye*, there are two relevant communities. On the one hand, the pediatric community accepts the hypothesis. On the other hand, the biomechanical engineering community regards the hypothesis as at best controversial.

#### Excited delirium

2 Giannelli et al., Scientific Evidence § 19.05[8] (2023 Supp.)

The diagnosis—birthed in a 1985 Journal of Forensic Sciences article, "Cocaine-Induced Psychosis and Sudden Death in Recreational Cocaine Users" by pathologist Charles Wetli and psychiatrist David Fishbain. They stated that in several cases they had been involved in, cocaine ingestion was "followed by bizarre and violent behavior, frequently accompanied by unexpected strength and hyperthermia" leading to death.

The early acceptance of the diagnosis

The criticism of the diagnosis—the contention that the diagnosis was abused in order to exculpate police officers whose conduct might otherwise have been listed as the cause of the asphyxiation that resulted in the decedent's death

the death of George Floyd

Ganeva, The Medical Examiner Said He Died of "Excited Delirium," Medical Experts Say Police Strangled Him to Death, The Appeal (Mar. 10, 2021)

The trend to abandon the diagnosis

The World Health Organization, the American Medical Association, the American Psychological Association, the American Psychiatric Association, and the Royal College of Psychiatrists as well as the National Association of Medical Examiners (NAME) and the American College of Emergency Physicians (ACEP), two organizations that had previously endorsed the diagnosis, no longer recognize the diagnosis as a cause of death.

California Evidence Code § 1156.5(b): "A party or witness may describe the factual circumstances surrounding the case, including a person's demeanor, conduct, and physical or mental condition at issue, including, but not limited to a person's state of agitation, excitability, paranoia, extreme aggression, physical violence, and apparent immunity to pain but shall not describe or diagnose such demeanor, conduct or condition by use of the term excited delirium, or attribute such demeanor, conduct, or physical and mental condition to that term."

In December 2023 the Colorado Peace Officers Standards and Training Board struck all references to excited delirium from its training materials.

11. Questioned Document Examination

A neuroscience approach

2 Giannelli et al., Scientific Evidence § 14.02[3][b][ii] (2023 Supp.)

The primary proponent of this new approach is Andrew Sulner, the principal of Forensic Document Examination, LLC in New York City. Sulner, Critical Issues Affecting the Reliability and Admissibility of

Handwriting Opinion Evidence—How They Have Been Addressed (or Not) Since the 2009 NAS Report, and How They Should be Addressed Going Forward: A Document Examiner Tells All, 48 Seton Hall L.Rev. 631 (2018).

Negatively, he rejects the categorical premises of the traditional approach: (a) inter-writer variability—each person's handwriting style is unique, and (b) intra-writer variability—no person can produce an exact duplicate of his or her signature or writing exactly the same way twice. After years in the field, he has concluded that there is simply insufficient empirical evidence to prove either of those two absolutist propositions.

However, affirmatively, a modern approach, resting on complexity theory and neuroscience research into human motor control, lends support to these propositions:

---The more complex a handwriting sample is, the more difficult it becomes for others to simulate it without leaving tell-tale indicia of simulation (e.g., line tremors, gaps, hesitations, etc.);

---The more complex a handwriting sample is, the more likely that it will contain features that deviate from other writers; and

---The greater the number of times a pen is required to change direction, the longer the line over which turning points occur; and the greater the overall speed of execution, the more complex the visual image appears.

In this light, two defensible principles emerge:

---Given an adequate number of skillfully executed, complex writings, the likelihood that handwriting by different writers will be distinguishable from each other is far greater than the likelihood that handwriting by different writers will be indistinguishable; and

---The smaller the source population of possible writers, the greater is the likelihood that a specific writer can be accurately identified as the source of a questioned writing.

The key is obtaining an adequate number of exemplars of contemporaneous, representative complex writings from all persons of interest. Even then, the examiner should refrain from using absolutist terminology. Rather, the examiner should specify the competing hypotheses (the two sets came from the same source versus the two sets came from different sources) and compare the strength of the evidence supporting one hypothesis with the strength of the evidence supporting the alternative hypothesis.

12. Trace Evidence such as Hair Examination

In the past two decades, microscopic examination of hair for identification has come under fire. In a 2002 FBI study, mtDNA testing revealed that 11% of the microscopic identifications were false positives. 3 Giannelli et al., Scientific Evidence § 24.02[17][b][1], at 24-35 (6<sup>th</sup> ed. 2020). Yet, mtDNA is much less discriminating than nuclear DNA. The emerging field of proteomics (protein analysis) has emerged to potentially supplant both methodologies. The protein content of hair is variable due to people's genetic makeup. Theoretically, the precise combination is different for each individual. Zhang et al., Sensitive Method for the Confident Identification of Genetically Variant Peptides in Human Hair Keratin, J. Forensic Sci. 406 (2020); Parker, Demonstration of Protein-Based Human Identification Using the Hair Shaft Proteome, 11(9), PLoS Ons, (2016).

There is an excellent description of the methodology in Jurenka, A Forensic Breakthrough: Proteomic Analysis of Hair for Individuation Evidence, 57 Crim.L.Bull. 164 (2021). The author describes the technique in this fashion:

---The analyst initially uses the "Orbitrap" MS method to investigate the sample's protein complement. This is a triple quadrupole system:

After traveling through one quadrupole, then being fragmented in a second

Quadrupole, the analyte vapor is fragmented and injected into the Orbitrap itself. The Orbitrap consists of three electrodes. These electrodes form a magnetic field within the Orbitrap causing the ions in the . . . vapor to spin around [a] central spindle. Analytes follow an oscillating orbit around the central spindle that is relative to the m/z value of the analyte.

---The analyst then resorts to database searching to identify the proteins. There are thousands of m/z spectra, but digital tools enable the analyst to simplify and expedite the search process. "A database search tool will begin by performing a digital trypsin-digestion of all relevant proteins in the database ( . . . hair shaft proteins). "The spectra in the analysis are compared to the spectra in the database; a degree of similarity is calculated for each, and a similarity score is assigned.

---Finally, "the investigator will . . . inspect the sequence of these proteins, compare them to a human genetic database, and uncover any rare amino acids present. An aggregation of rare amino acids will allow the investigator to associate the proteins extracted from the hair sample with an individual's genetic sequence." The analyst is searching for genetically variant peptides (GVPs).

Leading researchers have cautioned that more investigation is necessary. Dr. Glendon Parker has called for research with larger and more diverse groups. Given the currently available empirical data, Dr. Parker found modest discriminatory power, a maximum of 1 in 12,500 for the European American

population and 1 in 11,000 for the African American population—comparable to the discriminatory power of mtDNA. Research with proteomic analysis is ongoing at the Forensic Science Center at Lawrence Livermore National Laboratory and the University of California Davis.