THE FUTURE OF FORENSICS

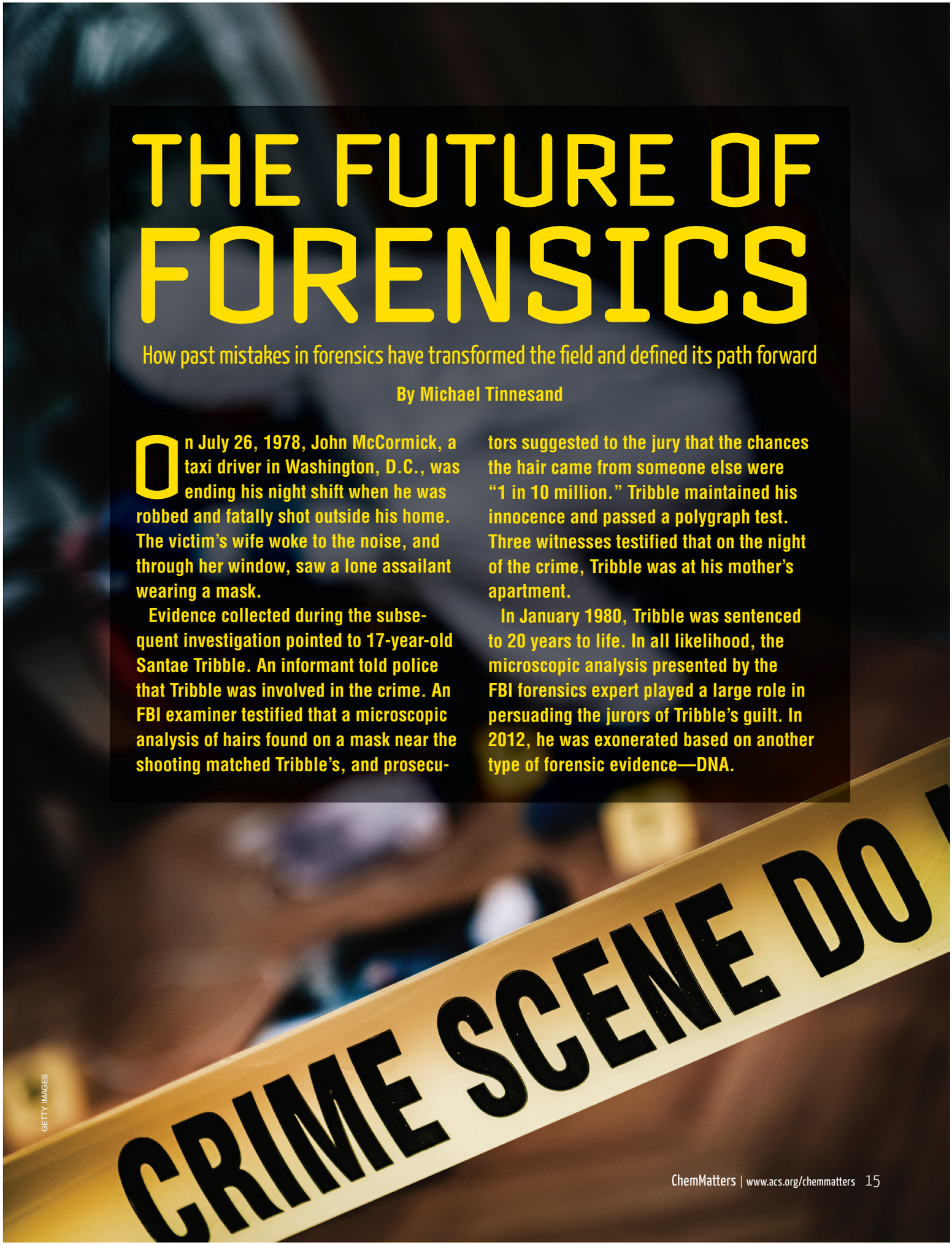
How past mistakes in forensics have transformed the field and defined its path forward

By Michael Tinnesand

On July 26, 1978, John McCormick, a taxi driver in Washington, D.C., was ending his night shift when he was robbed and fatally shot outside his home. The victim's wife woke to the noise, and through her window, saw a lone assailant wearing a mask.

Evidence collected during the subsequent investigation pointed to 17-year-old Santae Tribble. An informant told police that Tribble was involved in the crime. An FBI examiner testified that a microscopic analysis of hairs found on a mask near the shooting matched Tribble's, and prosecutors suggested to the jury that the chances the hair came from someone else were "1 in 10 million." Tribble maintained his innocence and passed a polygraph test. Three witnesses testified that on the night of the crime, Tribble was at his mother's apartment.

In January 1980, Tribble was sentenced to 20 years to life. In all likelihood, the microscopic analysis presented by the FBI forensics expert played a large role in persuading the jurors of Tribble's guilt. In 2012, he was exonerated based on another type of forensic evidence—DNA.



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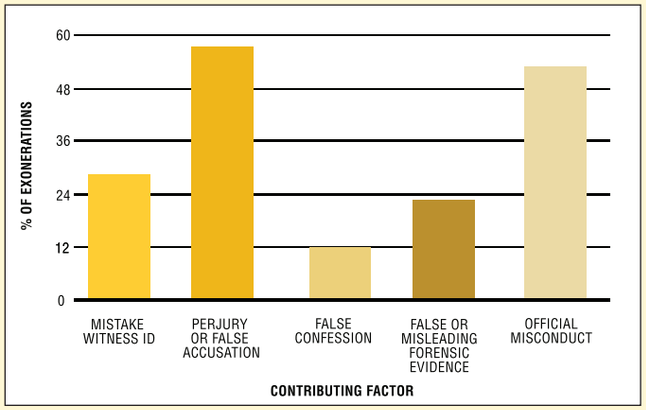
Fingerprint analysis isn't as reliable as it's often portrayed to be on television. One problem with the technique is that bias can affect whether an examiner matches a set of fingerprints to a suspect.

How the Wrong People End Up in Prison

Faulty forensics are undoubtedly a problem, but they are neither the only contributor to wrongful convictions, nor are they the largest contributor. Other factors, including false accusations and official misconduct, have also played significant roles in the incarceration of innocent people, as shown in this graph. The chart includes known exonerations dating back to 1989. (Note that the percentages do not add up to 100%; this is because multiple factors can apply to any given case.)



KELSEY CASSELBURY, SOURCE: THE NATIONAL REGISTRY OF EXONERATIONS

Forensics and its flaws

Tragically, Tribble's story isn't unique. He is one of many who have been imprisoned for crimes they didn't commit. The reasons why this happens are complex. Flawed forensics is one piece of the puzzle.

The term **forensic science** includes the word **forensic,** which means argumentation or debate. **Science** is defined as the systematic study of the world through observation and experiment. These two words seem at odds with each other. But our judicial system is set up as a debate about the guilt or innocence of the accused. Law enforcement collects physical evidence for this process to form a picture of what took place at the crime scene and to support legal arguments for or against the conviction of a person on trial. Sometimes, a single piece of evidence—a hair, a bite mark—can make or break a case.

A critical approach to piecing together what happened at a crime scene uses a process that is likely very familiar to you: the **scientific method.** This classic foundation for a way of thinking about solving problems is at the heart of criminal investigations. Investigators begin with making observations at the scene of the crime. They collect and consider pieces of evidence. If there appears to be a connection between the evidence and the crime, they develop a hypothesis. To test their hypothesis, they run tests or collect further evidence.

But the scientific method has not always been diligently applied to forensics. In 2009, a seminal report on forensics released by the National Academies of Sciences (NAS)—a U.S. institution that analyzes issues related to science—concluded that "[w]ith the exception of nuclear DNA analysis,…no forensic method has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source."

The report listed the following methods as techniques lacking in scientific validation: bite-mark analysis, microscopic hair analysis, shoe-print comparisons, handwriting comparisons, firearms and tool-mark examinations, and fingerprint examinations—previously the gold standard of forensic analyses.

One of the issues that emerged from the report is the subjective nature of some of these traditional forensic methods. For example, research has demonstrated that information can bias a forensics specialist. One study showed that if fingerprint examiners were told that a suspect was in custody, they were more likely to match a fingerprint to the suspect. As recently as 2009, standardized rules for fingerprint examination simply didn't exist.

The overall lack of rigor for thoroughly validating forensic methods in the past has had profound consequences for Tribble and others like him.

What works

The good news is that the field of forensic science has come a long way. Today, even forensics students could probably have debunked the FBI hair analysis in Tribble's 1978 case. Hair without DNA is considered **class evidence.** Class evidence has characteristics common to a group of similar objects, but not one single object. For example, a blond hair discovered at a crime scene may point an investigator in the direction of a blond suspect. But even though a hair collected at a crime scene might share similar microscopic characteristics with hair from a suspect, the strand might not have come from the suspect.

In contrast, DNA evidence is categorized as **individual evidence.** This means that it can be linked to a specific, unique source.

Technological advances over the past three decades and the rigorous science behind DNA analysis has led it to become a benchmark for forensic evidence. DNA evidence has allowed law enforcement to establish more reliable connections between individuals and crime scenes. It has also been a key tool in exonerating hundreds of people who have been wrongly convicted, according to the Innocence Project, a legal network that helps prisoners fight charges against them.

In 2012, *The Washington Post* retold Tribble's story when he was exonerated of the murder he was accused of. Tests that year showed that DNA from the hair in the mask did not match Tribble's, despite the original microscopic analysis that concluded otherwise. A private lab even determined that one of the hairs found in the mask belonged to a dog. But by then, Tribble had already served time for a crime he didn't commit. On his release, Tribble had spent more years in prison than out. In 2016, a judge ordered the District of Columbia to pay Tribble $13.2 million in damages.

In addition to DNA analysis, other reliable tools are available to law enforcement to aid them in investigations. **Gas chromatography** and **mass spectrometry** can identify chemicals such as drugs or other substances collected from a crime scene. Gas chromatography works by separating and analyzing compounds in a gaseous state. Mass spectrometry helps scientists identify molecules by measuring the mass-to-charge ratio of an ionized sample of a substance.

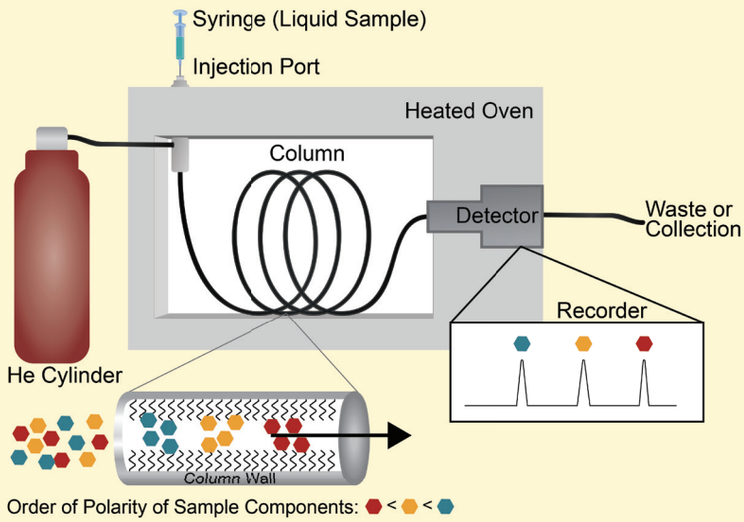
Crime labs can also use an instrument called a **Fourier transform infrared (FTIR) spectrophotometer.** FTIRs pass infrared radiation through samples, which can be solid, liquid, or gas. Some radiation is absorbed, stretching or bending bonds within a molecule. Some radiation passes through. The pattern of absorption and transmission is unique to a substance—a chemical fingerprint, so to speak.

Chemical Fingerprinting

At a crime scene, blood splatter, drugs, and other substances are often left behind, and it's not always obvious what's what. Identifying the various chemicals helps investigators figure out what may have happened.

Gas chromatography is one technique often used in forensic science to help positively identify the substances found at a crime scene. Here's how it works: A liquid sample is injected into a column, vaporized, and carried by an inert gas, such as helium, through a column. The column contains a material called a stationary phase that slows down the flow of the sample's components based on their polarity.

As a component passes through and exits the column, a detector records the component's signal. Polar molecules bind more tightly to the stationary phase, and therefore flow through the column more slowly.



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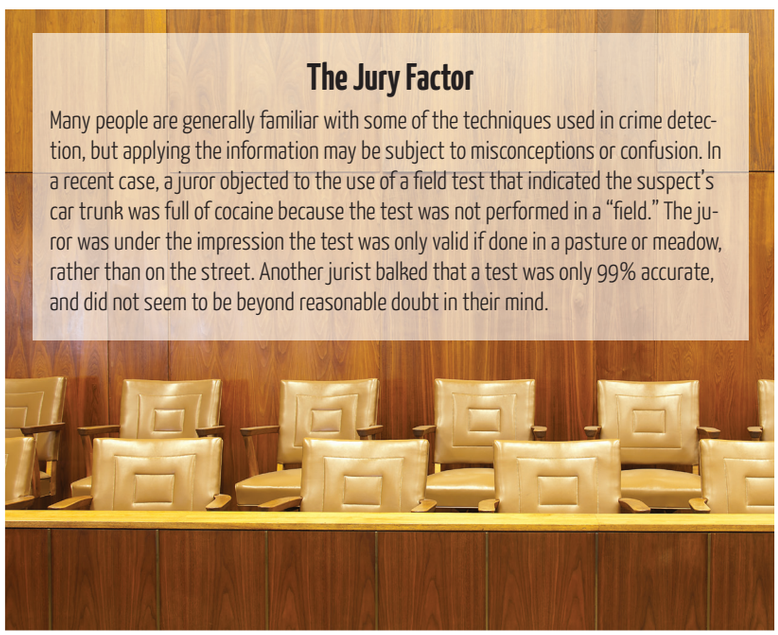

The Jury Factor

Many people are generally familiar with some of the techniques used in crime detection, but applying the information may be subject to misconceptions or confusion. In a recent case, a juror objected to the use of a field test that indicated the suspect's car trunk was full of cocaine because the test was not performed in a "field." The juror was under the impression the test was only valid if done in a pasture or meadow, rather than on the street. Another jurist balked that a test was only 99% accurate, and did not seem to be beyond reasonable doubt in their mind.

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TV forensics: What do CSIs actually do?

http://bit.ly/Reactions-CSI

Future of forensics

As for traditional forensic methods, researchers have tested and reviewed the limits of multiple techniques in response to the 2009 NAS report. In 2016, a follow-up report by the President's Council of Advisors on Science and Technology (PCAST) documented progress in forensic research. For example, scientists had studied the reliability of fingerprint analysis, and found that false positives were not uncommon, and examiner bias remained an issue. But recognizing that fingerprinting can still provide useful information, the PCAST report recommended that the technique's limitations be made clear to jurors for context.

Moving forward, the report further proposes that the scientific and law enforcement communities continue to work toward improved techniques to transform subjective methods into objective ones through research. Perhaps then, the reliability of these tests will help ensure that only the guilty are convicted.

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Testing in the Field

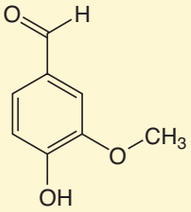
Police officers often use field tests to quickly determine whether someone is in possession of an illicit substance. Many of these field tests (quick analyses performed at a crime scene) involve a rapid color change that indicates the presence of a particular chemical compound.

Formaldehyde (CH_2O) and sulfuric acid (H_2SO_4) turn brown when applied to amphetamines and opium derivatives. Cobalt thiocyanate [$Co(SCN)_2$] changes color in the presence of cocaine and barbiturates, and sodium nitroprusside ($C_5FeN_6Na_2O$) is used to test for methamphetamines. The Duquenois-Levine (D-L) test, which involves vanillin ($C_8H_8O_3$), acetaldehyde (C_2H_4O), ethanol (C_2H_6O), hydrochloric acid (HCl), and chloroform ($CHCl_3$), is often used to screen a sample for marijuana.

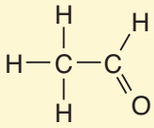
But field tests have limitations. A closer look at the D-L test demonstrates the reason for this.

Marijuana-containing plant material will develop a blue-purple color in reaction with the D-L reagent. No color indicates cannabinoids are not present in a sample. The test can't confirm, however, that a substance is definitely marijuana. Past studies on the field test have found that a variety of non-marijuana substances, including patchouli, cypress, and eucalyptus, yield positive results.

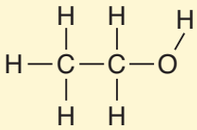
So, what a positive field test can't show is whether a substance in a person's possession is marijuana; it can only suggest that a substance might be. Because of this uncertainty, forensic labs have to run subsequent laboratory tests on samples of the same substance to confirm whether it's marijuana.



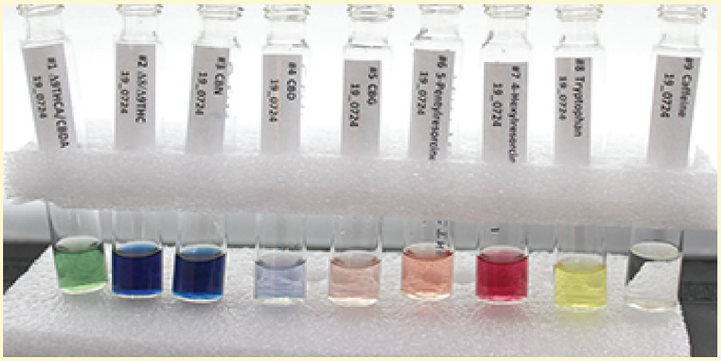
Vanillin, $C_8H_8O_3$



Acetaldehyde, C_2H_4O



Ethanol, C_2H_6O



Color-based tests are often used by law enforcement to determine whether someone is in possession of illicit substances. The D-L reagent (pictured), for example, changes color if a substance contains cannabinoids—but also other compounds not present in marijuana. Because the D-L test can yield false positives, forensic labs must run additional tests on a substance to confirm what is or is not in it.

PHOTO: COLORADO GREEN LAB, GRAPHICS: RS GRAPHX, INC.

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