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# International Association of Chiefs of Police

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## Executive Brief

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# Forensic Science: Bringing New Technology into the Crime Lab

*By Lois Pilant*

Sir Arthur Conan Doyle probably had no idea he was opening the door to a new generation of law enforcement when he created the character of Sherlock Holmes. With dry humor and typically British reserve, this accidental detective solved crimes by way of keen observation, deduction, and a brilliant assembly of the facts. Readers were astonished with the simplicity of Conan Doyle's solutions and the fact that Holmes was always, uncannily, right.

The public's fascination with crime solving has not diminished. Witness the popularity of the old television series *Quincy*. Although the show did little to glamorize medical examiners in the same way others have buffed up the image of patrol officers and detectives, it was one of the first to popularize forensic science.

Forensic science, or criminalistics, is one of the few areas of law enforcement where science and crime solving meet. It is vastly different than the domain inhabited by the detective assigned to interview victims and witnesses. Criminalistics moves out of that messy and often emotional arena and into the sterile environs of the crime lab. Here, the laboratory scientist deals with inanimate objects that cannot lie, fight, or flee.

Forensic science is based in the theory of transfer; that is, when two objects meet, some evidence of that meeting generally can be established and verified at a later time. Fingerprints left inside a burglarized house, shoeprints outside a window, toolmarks around a door—there are

thousands of examples of the minute bits of evidence found at a crime scene that are later used to incriminate, associate, establish, or convict. And with the advent of DNA profiling, those bits of evidence keep getting smaller and smaller, to the point that a link between a suspect and a crime can be made with as little as one skin cell.

Supporting the advancement of law enforcement and putting state-of-the-art technology in the hands of state and local police have been primary goals of the National Institute of Justice (NIJ) since its inception more than 20 years ago. As the research and development branch of the Department of Justice, the NIJ is the primary sponsor of criminal justice research in the United States.

The NIJ's Science and Technology Division has been instrumental in a number of areas, with grants that have advanced the science of DNA profiling and supported research into less-than-lethal devices. Forensic science has been an area of particular interest, with grants funding research as varied as photographing wound patterns that are invisible to the human eye, creating new fingerprint reagents, and developing comprehensive software programs on firearms or trace evidence.

One NIJ grant, funded in 1988, sponsored the successful development of a technique that revolutionized forensic odontology in the area of photographing bite marks. Dr. Elizabeth Robinson, formerly of the Case Western Reserve University Dental School, used a process called "toneline photography" to alleviate problems associated

## SCIENCE AND TECHNOLOGY



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with tracing bite marks on acetate overlays. Robinson found that tracing the marks left too much room for human error and subjectivity. Tracings by four different people resulted in four widely disparate drawings. Some drew teeth as circles, some as squares; in addition, teeth were drawn at dissimilar angles.

Toneline photography removes the possibility of human subjectivity and interpretational bias. The result of this somewhat complicated process is a picture that looks almost like a pen-and-ink sketch on a transparent background that can be compared directly to a model of the suspect's teeth. The process is inexpensive, portable, and available to any crime lab with access to a dark room and basic camera equipment. Robinson's research was a breakthrough in the area of forensic odontology and was instrumental in convicting an Ohio man of child abuse when it was admitted into evidence for the first time.

Another NIJ grant, also funded in 1988, combined the area of photography with the high-tech world of computers. The development of Restoretool, by Dr. Murat Tekalp of the University of Rochester in New York, uses a software program to restore and enhance blurred, grainy, or poorly contrasted photographs. Restoretool digitizes scanned photographs and allows the examiner to focus on one identifiable point, and minutely and precisely correct it. The program then uses those parameters to correct, enhance, or restore the rest of the picture.

The NIJ has continued in its efforts to support the forensic sciences. By funding a variety of grants, the agency's Science and Technology Division has added a host of new tools to law enforcement's arsenal of crime-solving weapons and has helped to advance what Sir Arthur Conan Doyle so unwittingly started in the late 1800s.

## Fingerprints

One of the most exciting breakthroughs in the area of fingerprints is the development of portable equipment that lets evidence technicians take the cyanoacrylate (superglue) fuming process to the crime scene. Even more exciting is the invention of a slender hand-held wand that, almost like magic, develops latent prints in 10 to 30 seconds.

The cyanoacrylate process was developed in 1979 after the Japanese police inadvertently found a fingerprint on the inside of the lid of a jar of superglue. By 1981, the fuming process was being used in America and Japan, and currently has worldwide applications.

Cyanoacrylate fuming has always been tedious, cumbersome, and confined to the crime lab. Because nothing is portable, evidence, regardless of its size, must be lugged back to the crime lab inside closed containers for processing. Processing involves putting three or four drops of glue in a small plastic dish or on a hot plate and using heat to generate the fumes. Fingerprints develop when the fumes from the glue adhere to the print.

The goal of **David E. Weaver**, of Alaska's Scientific Crime Detection Laboratory in Anchorage, was to bring the fuming process to the crime scene. With funding from an NIJ grant,

Weaver developed a portable vapor pump that allows technicians to process large crime scenes in one to two hours.

The vapor pump consists of a small compressor, a heat source, and a one-gallon vapor chamber. The compressor pumps air into the heated chamber, and vaporized cyanoacrylate is ejected through an exit hose inserted into the crime scene from an outside door, window, or a hole drilled through a wall. The device is controlled from the outside, with fingerprint development monitored via known prints on foil strips that have been placed near windows throughout the crime scene.

Weaver also developed a vapor pump for use inside a laboratory fume hood. This device uses heat acceleration and has the added feature of letting the technician control the direction of the spray. Prints can be developed in as little as 30 seconds. A crime lab can construct a similar apparatus by using an Erlenmeyer flask, a hot plate, and 1/2-inch flexible tubing. What makes both of these pumps so effective is their ability to move large quantities of cyanoacrylate at a higher rate than was ever possible with the old process.

Weaver then decided to miniaturize the process and came up with what may be the most extraordinary development in many years: the Vapor Wand. This device is slightly larger than a fountain pen and consists of a butane torch that has been fitted with a .223 brass cartridge casing that has been lined with steel wool and saturated, drop by drop, with methyl cyanoacrylate. The brass holder is fitted over the end of the butane torch and, when lit, emits a high concentration of the fumes to develop clear, indestructible, three-dimensional prints. One of the most exciting aspects of the Vapor Wand is that it is easy and inexpensive for crime labs to produce in-house.

Weaver also worked with the 3M Company's Graphics Research Team to modify the cyanoacrylate chemistry and produce dyes that could be mixed with it. By adding a magenta dye to the cyanoacrylate chemistry, a pink print appeared that fluoresced consistently under a laser. Lasers are not, however, the most cost-efficient way to visualize fingerprints. Less expensive is the use of ultraviolet light. According to Weaver, the next step in advancing the fuming process is to incorporate a dye that will fluoresce under ultraviolet light.

In another area of fingerprinting, an NIJ-sponsored effort is underway to develop versatile, affordable, and efficient reagents in the ninhydrin family. Dr. Madeleine M. Joullie', an organic chemist at the University of Pennsylvania in Philadelphia, is directing this research. Synthesizing compounds is nothing new to Joullie'; she has developed reagents for several federal and international law enforcement organizations.

Her work for the NIJ will be similar in that she and her team will create new reagents that are derivatives, or analogs, of the parent compound, ninhydrin, which is used to detect amino acids. Joullie' also has proposed the creation of a number of novel sulphha-containing compounds.

Characteristic of this kind of research is the unpredictable behavior of new compounds, a factor which necessitates a great deal of trial-and-error experimentation. Nevertheless, the possibilities for success are vast, primarily because the

needs of the industry are so great. According to Joulie', fingerprint examiners have expressed the need for reagents that will fluoresce without a secondary treatment; do not require the use of a laser; are more sensitive; have increased resolution; have good solubility in non-toxic, affordable solvents; are environmentally friendly and safe to use; can be used on a variety of surfaces; and do not fade with time. Additional goals include the possibility of creating a polymer that will result in a permanent print—like that which results from cyanoacrylate fuming—as well as reagents that will increase the accuracy and speed of processing and thereby help law enforcement keep up with advances in computer technology and AFIS systems.

## Photography

Although dermatologists have known about it for 50 years, it wasn't until a police photographer used black and white film to photograph a child abuse victim that law enforcement learned ultraviolet photography could be used to document wound patterns.

As often happens in science, it was an accidental discovery. A photographer had been using the film to do outdoor landscape photography. His next assignment was to photograph an alleged child abuse victim who had been in official custody six months. The photographer apparently decided to finish the roll of film with pictures of the child. Subsequent color pictures showed no injuries. But the black and white pictures showed numerous injuries under the skin, many of which were months old.

Ultraviolet (UV), (meaning, literally, "beyond violet"), light exists at the low wavelength end of the color spectrum and is invisible to the human eye. It can, however, be used in photography and will show remarkable detail and contrast to injured areas, many of which cannot be seen under normal lighting conditions. In fact, experiments have shown that bite marks that are impossible to see under standard lighting 21 days after infliction are obvious when observed with UV light.

Research in this area has been pioneered by two forensic odontologists with support from an NIJ grant. Dr. Michael H. West, deputy medical examiner investigator in Hattiesburg, Miss., and Dr. Robert E. Barsley, a professor at Louisiana State University's Department of Oral Diagnosis, have helped to solve crimes that at one time would have been impossible. In one case, a child was admitted to the hospital in extremely critical condition. Although the mother denied beating the child, UV photographs showed the imprint of a belt buckle on the child's back. In another case, a live-in maid bit a man who burglarized her employer's home. Ten weeks later, the man was arrested. Although he denied the charge, UV photographs showed a distinct bite mark that matched the maid's teeth.

UV photographs are difficult to take because light at this wavelength is invisible. The spot of the injury must be marked, and even then the investigator does not know if he was successful in documenting the evidence until the pictures are developed. This was one of the problems Barsley and West tried to alleviate by incorporating fluorescence

photography. With this technique, called "Alternative Light Imaging" or "Narrow-Band Illumination," investigators wear yellow goggles to filter out reflected light and use a high-intensity tunable light source to scan the victim with a blue light. This technique lets investigators see the changes brought on by a skin injury. The damage is then documented with a 35mm or video camera.

Alternative Light Imaging has been instrumental in solving a number of cases, including one in which a strangulation victim was found with the strap of her purse still wrapped around her neck. The slide-hook fastener on the purse strap broke during the assault. The murderer held the broken end in his hand as he tightened the noose around the victim's neck. Using Alternative Light Imaging, investigators were able to see the pattern the fastener left in the palm of the suspect's hand. In addition, shoeprints were much more clearly visible on the victim's face when viewed with Narrow-Band Illumination.

## Gunshot Residue

Dr. Peter DeForest, professor of criminalistics at John Jay College in New York, is also working in the area of photography under one of the NIJ's most recently awarded grants. DeForest's work has three aspects, one being the use of high-speed photography to document gunshot residue (GSR) as it is being formed.

Over the past several years, tests designed to detect GSR on a suspect's hand have become more sensitive and sophisticated, able to detect minute traces of the compounds found in GSR, such as antimony, barium, and lead. Unfortunately, what has been sacrificed is the ability to map the pattern of distribution.

The original GSR test for hands used paraffin. Investigators cast the suspect's hand in hot wax, which, when cooled, was cut open and sprayed with a reagent. If areas inside the cast turned blue, it was an indication that the suspect had been in contact with nitrates, a reaction characteristic of firing a gun. The problem was that other substances, such as urine and cigarettes, caused the same reaction. Because the test results were too ambiguous, the procedure fell into disuse in the late 1950s.

A variety of tests later were developed, each with their own attributes but also their own deficiencies. And though the science of detection advanced, the ability to map a GSR pattern on a subject's hand was lost when police stopped using the paraffin test. DeForest's work will address that problem, and will, with the help of high-speed photography, document GSR clouds and the effect on a subject's clothes and his surroundings. DeForest plans to use cameras, including a 4x5 large-format camera and a microflash that emits an extremely short, intense burst invisible to the human eye to document exactly what happens when a shot is fired. The resulting photographs should show how far particulates travel at a certain velocity, how they distribute in space, what happens to the GSR cloud when high-velocity ammunition is used, the differences between various types of ammunition, and the differences between a clean weapon and a dirty one.