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Historical References and Doctrinal Precedents of Forensic Science Worldwide

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ABSTRACT: Forensic science owes its origins to the people who developed the principles and techniques needed to identify and compare physical evidenceas, well as those who recognized the need to consolidate these principles into a coherent scientific discipline. Evidence of forensic science dates back to antiquity, but it was not until the 19th century that science was rigorously applied to criminal cases through advances in the way criminal cases were handled, which improved the validity of the conclusions drawn from investigations by the judicial authorities. Many steps have also been taken to organize specialist areas within police departments, including forensic science. Furthermore, forensic science has literary roots, as evidenced by the forensic novels written by famous authors, which were based on the methods, techniques and tactics used in forensic science. This article contains a brief analysis of some of the key moments and doctrinal precedents in the history of forensic science, seen in the evolution of its subfields. Such insights aim to provide readers with a deeper understanding of the current state and trends of this science.

KEYWORDS: forensic science, forensic medicine, genetics, dactyloscopy, ballistics, forensic novel, forensic laboratory

Introductory aspects

Forensic science owes its origins, firstly, to the people who developed the principles and techniques needed to identify or compare physical evidence and, secondly, to those who recognized the need to unify these principles into a coherent scientific discipline (Saferstein 2011, 11). Since ancient times, the search has been on for an infallible means, an irrefutable piece of evidence that would stigmatize the offender and enable him to be identified (Lăpădusi 2011a, 704). The main forensic investigative tools used to identify perpetrators have been the observation and interpretation of physical evidence (Eckert 1997, 11). It was not until the 19^{th} century that science was rigorously applied to these tools through advances in the way files were investigated, which improved the validity of the conclusions drawn from investigations by the judicial authorities. Steps were taken to organize specialist areas within police departments, including forensic science.

The origins of forensic science

The developments in forensic science have not been uniform throughout the world. Concerns to establish methods for detecting crime and criminals have been around since ancient times, but at first, they were isolated practices and only gradually, and not always scientifically, did they develop into independent research methods. Forensics was established as an autonomous judicial science at the end of the 19^{th} century, separating from Medical-legal science (Buzatu 2013, 15).

Medical-legal science

The origins of medical-legal science date back to antiquity, with the timid attempt to determine the degree of guilt of an offender on the basis of scientific criteria, given that forensic knowledge was initially a monopoly of the priest who also performed the social function of the judge. In ancient Egypt, the laws of Menes required a matron to examine a woman sentenced to death who, in order to prolong her life by a few months, claimed to be pregnant.

Among the ancient Greeks, Hippocrates weighed in the judge's judgment his personal finding regarding the moral disturbances caused to virgins by an untimely menstruation. When examining the charge of abortion, Greek judges invoked the authority of Aristotle, who had fixed the fortieth day after conception as the time of foetal insemination.

In Romans, the *Digest* stipulates that the judge shall not pronounce in cases of doubtful pregnancy without the prior opinion of a midwife. *The Lex Aquilia* devotes a special chapter to the examination of wounds in terms of their lethality (Minovici 1928, 2).

Gradually, medicine is gradually taking away bit by bit its authority to impose itself in the guidance of justice. Thus, in the Salic Law and in the Chapters of Charles the Great, as early as the year 800, the need for medical intervention in certain cases brought before the courts is formally proclaimed.

The first decisive step in this direction was taken by Emperor Charles the Fifth, who, in his *Constitutio criminalis Carolina,* promulgated in 1532 at Regensburg, decided that in certain circumstances, justice must necessarily have recourse to the services of the doctor to help and enlighten it in the resolution of the case in question. The promulgation of this law is considered the most important date in the evolution of the philosophical spirit of medieval society, putting an end to judicial arbitrariness and thus establishing the scientific control of legal medicine.

The one who gave the science of forensic medicine its full scope is Paul Zacchias who in 1621, through his work *"Paul Zacchiae, medici romani, opus jurisperitis maxime necesarium, medicis per utile, coeteris non in jucundum"* raised forensic medicine to the rank of a science that required for its evolution to use results obtained from other sciences.

The second half of the 17th century saw the beginning of the period of rigorous scientific certainty, for example, in 1753, through his study of the types of death, Louis made a valuable contribution to the signs of death and highlighted the anatomical characteristics of death by hanging. Following the contribution of other researchers in the following centuries, the field of forensic medicine improved with findings on the signs of death, the process of decomposition, the characteristics of identity, the effects of wounds caused by weapons, the causes of death, injuries to the intellect, etc. (Minovici 1928, 2).

Advances in both medicine and science in general have contributed to a considerable increase in the use of medical evidence in court. In addition, other types of scientific evidence began to evolve only in the 18th and 19th centuries, a period in which the level of human knowledge developed, leading to the emergence of different sub-branches of medicine, such as forensic psychiatry, which will be discussed below (White 2004, 3).

Forensic psychiatry

The beginnings of forensic psychiatry, as a specialty of forensic science, is linked to the Daniel M'Naughten case in England-1843, in which a madman shot a government official and was found guilty by virtue of the madness he suffered from.

This case has gone down in the history of forensic medicine as the "M'Naughten rule," according to which every person is presumed to be of sound mind and in order to establish a defense on the ground of insanity-mental insanity, it must be proved that at the time of the commission of the offence, the offender was under a defect of reason due to mental disease so that, if necessary, he had no representation of the nature and consequences of the act committed or if he had knowledge of such a situation, he had no representation that he would commit a crime. One of the leaders in this field of psychiatry was Dr. Isaac Ray (1807-1881), the father of American forensic psychiatry, who wrote a *"Treatise on the Medical Jurisprudence of Insanity"* in 1838. Dr. Quen, another leading representative of forensic psychiatry, had previously written about earlier historical aspects of forensic psychiatry in America, realizing once again the close connection between psychiatry and law.

The cases that have dealt with such a situation are summarized and synthesized in this treatise, which has exerted a vast influence in case law. For example, an effective implementation of the ideas in the treaty was pointed out to the court by the defense counsel in the court case brought against Daniel M'Naghten in 1843, to which I referred above. At trial, counsel quoted extensively from the treatise, rejecting traditional views of insanity; the defense thus relied on the defendant's ability to distinguish 'what is right from what is wrong' in favor of a broader approach based on causation.

Criminal profiling is another approach to support police investigation of cases, based on a study of the serial killer's behavior, so that a suspect can be assessed before and after being taken into custody.

Forensic toxicology

From prehistoric times there was also a rudimentary knowledge of forensic toxicology, as a sub-branch of forensic medicine, when plants were first used by man for their poisonous content in fishing, hunting and for destroying human enemies (see also Buzatu 2012, 27 and Buzatu 2015, 1). Early Indian and Egyptian writings included references to poisons and antidotes. Greek and Roman literature recorded the use of poisons and venoms from plant sources for suicidal and homicidal purposes. In 339 BC, Socrates was executed with a poisonous extract of hemlock. In 331 BC, a mass poisoning took place in Rome. In 300 BC, Theophrastus wrote a history of plants and mentioned plant poisons and their actions.

Before and during the Renaissance, poisoning became an art, with the histories of European courts full of poisoning deaths of kings, popes and nobility. The guards tasted the food and drank the wine intended for the royal table. Professional poisoning took place until the 19th century. In England, Henry III punished a poisoner by boiling to death. The most common poisons during this period were hemlock, aconite, opium, arsenic and corrosive sublimate. Autopsies and chemical analyses were rarely performed until Joseph Jacob Plenck declared in 1781: "The only sure sign of poisoning is the chemical identification of the poison in the organs of the body" (White 2004, 31).

Toxicological analysis of organs in human bodies was rarely carried out before 1900 due to the primitive development of the forensic investigation system. Elected coroners were laymen with little scientific knowledge. It took the change in the forensic investigation system in Massachusetts in 1877 and in New York in 1918 to reintroduce the importance of proper postmortem toxicology into forensic investigations. If a case was notorious and an examination of the mode of poisoning was needed, the coroner sought the services of a professor of chemistry. During the 1890s, Dr. Alexander O. Gettler noted in his review of the history of toxicology that it took one such professor 20 months to analyze the organs of a postmortem case. After the end of the Second World War, the "age of instrumentation" began. Instrumentation allowed more precise quantification of toxic substances in tissues and multiple testing with automated equipment. Combining automated equipment with computers allowed multiple analyses, calculations, and printing and storing of results.

Forensic odontology

From the perspective of forensic odontology, the examination of dental samples and dentures has been reported as early as 2500 BC, when two molars bound together with gold wire were found in a tomb in Giza-Egypt. Tooth impressions were used as seals for personal identification more than 900 years ago. In 66 AD, Nero killed his wife and presented her head on a plate to his mistress, who identified the head by the malformation of a blackened tooth.

One of the earliest cases in which dental samples were used for identification in America involved the death of Dr. Joseph Warren in 1775. A physician and leader of Americans concerned with independence, Dr. Warren was killed during the Battle of Bunker Hill and buried in a mass grave. Paul Revere, who had made him a denture containing a silver and ivory bridge, later identified Dr. Warren's body using this bridge (White 2004, 37).

The first identification of a bite mark was made on a piece of cheese left at a crime scene. When compared to the teeth marks of the robbery suspect, the dental evidence led to a conviction in the case in 1906 at Cumberland Assizes in Carlisle, England.

Bite evidence is one of the most interesting applications of dental forensics because it provides an unusual direct link between an offender and a victim. A 1949 murder case in Tunbridge Wells, England, provides a clear example where investigations by dental experts revealed that dental impressions taken from the victim's bite marks matched those of her husband. Perhaps the most important and useful application of the forensic dentist's expertise is the management of victim identification in mass fatalities, such as aviation disasters and wartime military deaths. After World War II, mass graves of victims of war crimes and military operations were opened for identification. In one such case, Strom in Norway identified more than half of the 211 Norwegians killed by the Nazis during the occupation.

Both dental and fingerprint examinations contribute significantly to the identification of transport accident victims. The importance of the dental examiner was recognized in the late 1960s when disaster response teams were organized. When jumbo jets crashed at Tenerife airport in the Canary Islands in March 1977, the American and Dutch governments sent teams of forensic experts to support the local authorities. The arrival of the Dutch identification team allowed them to collect dental samples from the Dutch victims by removing their upper and lower jaws, leading to their identification process, while the Spanish authorities ran their investigation in parallel, also allowing the identification of the bodies.

Forensic genetics

The use of genetics has been rapidly adopted by the forensic community and now plays an important role worldwide in both crime investigation and relationship testing.

In 1900, Karl Landsteiner described the ABO blood grouping system and noted that individuals could be placed into different groups according to their blood type. This was the first step in the development of forensic haematogenetics (Goodwin 2011, 2).

In the 1960s and 1970s, developments in molecular biology, including restriction enzymes, *Sanger* sequencing and *Southern blotting*, allowed scientists to examine DNA sequences. By 1978, DNA polymorphisms could be detected using *Southern Blotting*, and in 1980 the analysis of the first strongly polymorphic *locus* was reported, in which polymorphism was caused by allele length differences.

It was not until September 1984 that Alec Jeffreys realized the potential forensic applications of *minisatellite loci*. The technique developed by Jeffreys involved extracting DNA and cutting it with a restriction enzyme before performing agarose gel electrophoresis, Southern blotting and probe hybridisation to detect *polymorphic loci*. The end result was a series of black bands on X-ray film, which was termed *DNA fingerprint-DNA fingerprinting.*

In the case of the first DNA fingerprints, multilocus probes (MLPs) detected multiple minisatellite loci simultaneously, leading to multiple band patterns. While multi-band fingerprints were very informative, they were difficult to interpret. New probes were designed that were specific to a single locus (single locus probes, SLP) and therefore produced only one or two bands for each individual. Minisatellite analysis was a powerful tool, but suffered from several limitations: a relatively large amount of DNA was required, it did not work with degraded DNA, comparison between laboratories was difficult and analysis was timeconsuming. Even so, the use of minisatellite analysis using SLP was common for a few years until it was replaced by *polymerase* chain reaction (PCR)-based systems.

A key development in the history of forensic genetics occurred with the advent of a process that can amplify specific regions of DNA - PCR. The PCR process was conceptualized in 1983 by Kary Mullis. The development of PCR has had a profound effect on all aspects of molecular biology, including forensic genetics, and in recognition of the significance of the development of the technique, Kary Mullis was awarded the Nobel Prize in Chemistry in 1993.

PCR increases the sensitivity of DNA analysis to the point where DNA profiles can be generated from just a few cells, reduces the time it takes to produce a profile, can be used with degraded DNA and allows analysis of almost any polymorphism in the genome.

The first application of PCR in a forensic case involved the analysis of single nucleotide polymorphisms within the *human leukocyte antigen* (HLA)-*DQα locus* (part of the major *histocompatibility* complex (MHC)). This was shortly followed by short *tandem repeat* (STR) analysis, which are now the most commonly used genetic markers in forensic science. The rapid development of DNA analysis technology includes advances in DNA extraction and quantification methodology, the development of commercial PCR-based typing kits and equipment for the detection of DNA polymorphisms. In addition to technical advances, another important part of the development of DNA profiling that has had an impact on every field of forensic science is quality assurance. The admissibility of DNA evidence was seriously challenged in the US in 1989 - *People* v. *Castro*; this case and subsequent cases in many countries have led to increased standardization and quality assurance in forensic genetics and other areas of forensic science (Goodwin 2011, 2). Accreditation of both laboratories and individuals is therefore an increasingly important issue in forensic science. The combination of technical advances, high levels of standardization and quality has led to the recognition of forensic DNA analysis as a robust and reliable forensic tool.

Material forgery and falsification of documents

Forgers also date back to antiquity. Suetonius claimed that Titus was the greatest forger of his age. Likewise, *Procopius* spoke of Priscus of Emes, who forged the writing of his contemporaries and was only exposed by his confession.

The Roman judge Quintilianus used a bloody fingerprint to acquit a young man accused of killing his father (Cârjan 2005, 17). Also, from the time of ancient Rome - *Lex Cornelia de falsis* and in the time of Justinian - *Noves 49 and 73 of 539*, the first known regulations appeared in the control of allegedly forged documents by which forgeries could be detected (Suciu 1975, 28). Thus, Justinian mentioned in Novela 73 a miscarriage of justice due to experts who considered a document to be a forgery whose authenticity was later established, noting that "the resemblance of the writings seems to me very suspicious: it is an argument which has deceived us a thousand times; we shall not be able to refer to it until we have better evidence." Justinian also denied in Novela 49 that certainty could be obtained by graphic expertise, taking steps to ensure the authenticity of the pieces serving for comparison.

In 1370, Charles V ruled on a forgery affair involving the nobleman of Riviere, the king's first chamberlain.

Francois Demelle published in France in 1609, *"Avis pour juger les inscription en faux"* (Notice for judging false inscriptions).

In 1699, Etienne de Blegny, author of one of the first treatises on forensic medicine, described the procedures for checking handwriting.

The 19th century was considered by Edmond Locard to be the "painful period" of graphical expertise in which momentous causes put experts in painful situations. In the "Affair of the Ronciere" the experts clarified the objectives of the graphic expertise but their conclusions were ignored by the court, a first discredit of the experts. The situation became tragic with the "Dreyfus Affair-1894" and laughable with the “Crawford-Theres Humbert Affair”. A remarkable progress was made in graphology, which tended to study more than the shape of letters and the general characters of graphism. It is the person who does the writing (Cârjan 2005, 17).

The immutable drawing

From antiquity also dates *the immutable drawing* representing particular reliefs, also known as patterns, drawings or particular prints. These appear on the walls of a Neolithic dolmen, on Chinese seals from the 3rd century BC and on Greek amphorae dating from the same period. One of the most telling pieces of evidence is an ancient Indian carving found in Canada at the edge of Kejimkoojik Lake, in the outline of a hand on the volar side where papillary patterns and flexion folds are traced. Their significance remains unclear. Also dating from the Neolithic are several red and black prints belonging to primitive people, discovered by Regnault in the Gargas Cave. In 100 AD, Roman pots made of clay and brick were found with the makers' imprints. Also, in the 1200s, the Chinese distinguished two types of finger designs: ‘lo’ and ‘ki’ (Cârjan 2005, 18).

Dactyloscopy

The invariability of papillary patterns, to which the *emergence of dactyloscopy* is linked, has attracted the attention of many people with interests in various fields. For example, some Chinese porcelain art manufacturers marked their works with the personal drawing of the left hand's polycryptol fingernail, which represented an inimitable imprint and was imprinted in such a way as to last as long as the work existed (Lăpăduși 2011a, 704).

The papillary ridges that form the designs on the fingers have always been so conspicuous that their study has led to the conclusion that they do not match one another from one individual to another, and not even one finger, hand or foot resembles another.

The first to interpret papillary lines was John Evangelist Purkinji who in 1823 made the first classification of papillary impressions into nine configurations (Lăpăduși 2011b, 752).

Hurscheke published a paper in 1845 in which he drew attention to the variety of papillary drawings and seven years later, in 1852, Herman Wellcker began a study of papillary ridges from his own hand which he continued in 1897, finally publishing two illustrative figures in the work “Archives de Gross.”

In 1877, William Jerschel, a British civil servant in the Indian Civil Service, first noticed the strange marks left by dirty hands-on wood, glass and paper. These were impressions made up of lines, arches, loops and vertebrae. This was the beginning of his first systematic studies of fingerprints, which led to the introduction of fingerprint recording in a district of India.

A Scottish physician, Henry Faulds, published the results of research in 1880, concluding that papillary line drawings do not change over a lifetime and can therefore be used for identification purposes better than photography. In fact, William Herschel and Henry Faulds embraced the idea of using fingerprints to detect criminals.

Francis Galton, a British anthropologist and cousin of the famous Charles Darwin, is considered the founder of police fingerprinting and the founder of biometrics by developing a comprehensive study of fingerprints from the biological aspect of heredity and race. In 1890, he developed a method of classifying offenders' records according to the shape of papillary drawings, using which he found a pre-existing record in a larger collection of records.

In 1899, Edward Richard Henry presented his fingerprint classification system based on the triangle called “delta” and five basic drawings, after which he published his work *“Classification and uses of fingerprints”,* considered the “bible” of English dactyloscopy. In

1900, England became the first European country to introduce the dactyloscopic system of identification and in 1901 established the Scotland Yard Fingerprint Foundation.

Ironically, in 1902 and outside the borders of England, Alphonse Bertillon identifies the perpetrator of a murder (Lăpăduși 2011b, 752).

Ballistics

As with any evolving science, the exact origins of forensic firearms identification are shrouded in obscurity. It will probably never be known exactly when it was first observed that bullets fired from a particular gun had a number of grooves printed at equal distances, all angled in the same direction and at the same angle, and which were the same on every bullet fired from that gun. It will also never be known when the next logical step was taken to compare the width, number and degree of inclination of the grooves with those on guns of another make. The next step, however, required a quantum leap in ballistics to demonstrate that all bullets fired from the same gun had microscopic striations (parallel printed lines) that were unique to the gun in which they were fired (Heard 2008, 147).

The first instances of bullet identification date back to June 1900, when an article by Dr. A.L. Hall appeared in the *Buffalo Medical Journal,* showing that bullets fired from different makes and types of guns, of the same caliber, had wound marks of different types. Unfortunately, Dr. Hall never developed his original article.

In 1907, following riots in Brownsville, Texas, where members of the U.S. infantry opened fire, personnel at the Frankfort Arsenal were tasked with identifying which of the guns had been fired. As a method of identification, enlarged photographs of the firing pin prints on the shell casings were used. By this means, they were able to identify with certainty that of the 39 cartridge cases examined, 11 came from one gun, 8 from the second, 11 from the third and 3 from the fourth. The remaining six cartridges were not identified.

As for the recovered bullets, the examiners concluded that they did not bear any distinguishing marks relating to the weapon from which they were fired. The only conclusion reached was that after the rifling characteristics, the bullets were fired from either a Krag or a Springfield rifle.

Later, in 1912, Victor Balthazard made the next profound breakthrough in this science, making photomicrographs of bullet surfaces and grooves in an attempt to identify the weapon from which the bullet was fired. Following these examinations, he concluded that the cutting edge used to rifle a barrel never leaves exactly the same marks in its successive excursions through the barrel. These marks, which by inference must be unique to that barrel, are then imprinted as a series of striations on any bullet that passes through that barrel. Thus, he argued that it is possible to identify, beyond reasonable doubt, that a bullet fired came from the barrel of a particular gun and not another. The significance of Balthazard's work cannot be overstated, as the entire modern science of bullet identification is based on this premise.

In 1923, in the *Annales de Medicine Legale*, De Rechter and Mage published a paper discussing the advantages of using firing pin prints to identify the weapon used. Around the same time, Pierre Medlinger also noted the reproduction of minute irregularities of the breech face on the soft brass of American primers. However, the matter was not pursued further without mention of the possibility of identifying the weapon fired (Heard 2008, 148).

It was not until 1925 that a comparison microscope was first mentioned, which allowed simultaneous viewing of enlarged images of two bullets or cartridge cases for preliminary comparison. In an article published in the 1936 edition of the *Chicago Police Journal*, Calvin Goddard attributed the development of the comparison microscope to a Philip Gravelle in 1925 who claimed it was a development of the comparison microscope used by Albert Osborn for examining documents.

Leading forensic personalities

From another perspective, we believe that countless people can be mentioned in the course who have contributed to the evolution and progress of forensic science, an aspect to which we have sporadically referred above. Without, however, making an exhaustive list, we will briefly present some of the leading figures in this science, whose undeniable merit led to the emergence and development of this science (Saferstein 2011, 11).

Mathieu Orfila (1787-1853) is considered the father of forensic toxicology. A native of Spain, he eventually became a renowned professor of medicine in France. In 1814, Orfila published the first scientific treatise on the detection of poisons and their effects on animals. This treatise established forensic toxicology as a legitimate scientific endeavor.

Alphonse Bertillon (1853-19N14) devised the first scientific system for identifying people. In 1879, Bertillon began to develop the science of anthropometry as a systematic, distinct procedure of taking a series of body measurements as a means of distinguishing one individual from another. For nearly two decades, this system was considered the most accurate method of personal identification. Although anthropometry was eventually replaced by fingerprints in the early 1900s, Bertillon's early efforts earned him the distinction of being known as the "father of criminal identification."

Francis Galton (1822-1911) undertook the first definitive study of fingerprints and developed a methodology for classifying them. In 1892 he published a book entitled *"Fingerprints"*, which contained the first statistical evidence supporting the uniqueness of his method of personal identification. His work went on to describe the basic principles that form the current fingerprint identification system.

Leone Lattes (1887-1954) discovered in 1901 that blood can be grouped into different categories. These blood groups or types are now recognized as A, B, AB and O. The possibility of blood grouping being a useful feature for identifying a person intrigued Dr Lattes, a professor at the Institute of Forensic Medicine at the University of Turin in Italy. In 1915 he devised a relatively simple procedure for determining blood group from a dried blood stain, a technique he immediately applied to forensic investigations

Calvin Goddard (1891-1955) made a considerable contribution to ballistics. In order to determine whether a particular weapon fired a bullet, it is necessary to compare the bullet with one that has been tested with the suspect's weapon. Goddard, a colonel in the US Army, perfected the techniques of such an examination through the use of the comparison microscope. Goddard's expertise established the comparison microscope as the modern firearms examiner's best indispensable tool.

Albert S. Osborn (1858-1946) initiated and developed the fundamental principles of document examination and is credited with the acceptance of document examination as evidence by the courts. In 1910, Osborn authored the first major text in this field - *Questioned Documents.* This book is still considered a primary reference for document examiners.

Walter C. Mccrone (1916-2002) conducted research in forensic science in parallel with the amazing advances in sophisticated analytical technology. During his lifetime, however, McCrone became the world's foremost microscopist. Through his books and articles published in various journals, as well as his activities in various research institutes, McCrone was a tireless advocate for the application of microscopy to analytical problems, especially to cases investigated by forensic means. McCrone's exceptional communication skills have made him a much sought after instructor and he has been responsible for educating thousands of forensic scientists worldwide in the application of microscopic techniques. Dr. McCrone has used microscopy, often in combination with other analytical methodologies, to examine evidence in thousands of criminal and civil cases over a long and illustrious career (Saferstein 2011, 8).

Hans Gross (1847-1915) wrote the first treatise describing the application of scientific disciplines to criminal investigations in 1893, in which he used the concept of *"Criminalistics"* *for the* first time worldwide. A public prosecutor and judge in Graz-Austria, Gross spent many years studying and developing the principles of criminal investigation. In his classic book *“Handbuch für Untersuchungsrichter als System der Kriminalistik”* (later published in English under the title *"Criminal Investigation"*), he detailed the assistance investigators could expect from the fields of microscopy, chemistry, physics, mineralogy, zoology, botany, anthropometry and fingerprinting. Subsequently, he founded and published the forensic journal *“Archiv für Kriminal Anthropologie und Kriminalistik”*, which still serves today as a medium for reporting improved methods of scientific crime detection.

Edmond Locard (1877-1966), a French citizen, demonstrated how the principles outlined by Gross could be incorporated into a functional forensic laboratory (in spite of the fact that Hans Gross was a strong advocate of the use of the scientific method in criminal investigation, but without making specific technical contributions to this methodology). Locard’s formal education was in both medicine and law. In 1910, he persuaded the Lyon police department to give him two attic rooms and two assistants to set up a police laboratory. In Locard’s early years, the only instruments available were a microscope and a rudimentary spectrometer. However, his enthusiasm quickly overcame the technical and monetary shortcomings he faced. From these modest beginnings, the research and results Locard arrived at were his major achievements that became known worldwide to forensic investigators. Eventually, he became the founder and director of the Institute of Criminalistics at the University of Lyon, which quickly developed into a leading international centre for forensic studies and research (Saferstein 2011, 8). From the results of his forensic work, some basic ideas stand out:

- from a forensic point of view, whenever two objects come into contact with each other, an exchange of materials takes place between them.
- when a person comes into contact with an object or a person, there is a cross-transfer of matter and materials (Locard's principle of exchange).
- each murderer can be linked to a crime committed by different particles transported from the crime scene.

After the First World War, Locard’s successes served as an impetus for the formation of police forensic laboratories in Vienna, Berlin, Sweden, Finland and the Netherlands.

Dr. R. A. Reiss (1875-1929), a specialist in chemistry and physics at the University of Lausanne, contributed greatly to the use of photography in forensic science and established one of the world's first forensic laboratories, which served the academic community and the Swiss police. His interests included photographing crime scenes, corpses and bloodstains. In 1913 he made a trip to Brazil, where his forensic expertise was presented for the first time in the Western Hemisphere (Dillon 1977).

In Italy, *Dr. Salvatore Ottolenghi* (1861-1934) founded the Scientific Police School in Rome, designated as the world's first renowned school for training police officers in scientific techniques. He included training in physical evidence and established a laboratory to provide scientific analysis for the police in 1908. This laboratory served both the police in Italy and the city of Rome.

In England, *C. Ainsworth Mitchell* (1867-1948) was a public analyst primarily interested in “disputed” documents and ink chemistry in the early 20th century. His compatriot, *Robert Churchill*, a famous English gunsmith, carried out numerous examinations of firearms in many cases in England (Eckert 1997, 34). Inspired by the use of the comparison microscope in forensic science in the USA, he commissioned such a microscope and used it himself in his ballistic examinations (Heard 2008, 148).

Literary roots of forensics

It is a universally acknowledged fact that art and literature have influenced forensic science to such an extent that one can speak of the *"literary roots"* of *forensic* science (Saferstein 2011, 11), more specifically the *forensic novel*, which focuses more on the forensic investigation, i.e., the forensic methods, techniques and tactics used and less on the analysis of the criminal (which is of particular interest to criminology).

More often than not, the criminal is left in the background and his role exists more to stage a mysterious crime. The focus is mainly on the emotional description of how the crime is discovered and the struggle between the prosecution and the defense, or the moral struggle and the legal mechanism that makes it possible to punish the offender (Pop 2020, 291).

A prime example is the work of *Agatha Christie* (1890-1976), the best-selling novelist of all time. She is known for her 66 crime novels and 14 collections of short stories, as well as the world's longest-running play - *"The Mousetrap" (*https://www.agathachristie.com/en/about-christie#discover-more*)*. It has been estimated in literature that Agatha Christie's novels are the most published of all time, second only to the Bible and the works of Shakespeare (Monico 2021, 7). The detectives created by the author are constrained by technology, resources and the criminal justice system of the 1900s. These are mainly Hercule Poirot and Miss Marple, his most popular detectives.

Hercule Poirot is Agatha Christie's most famous detective. Often described as a small man with a big ego and an even bigger moustache, Poirot is everything most readers want from a traditional detective. As a retired Belgian police officer, Poirot brings with him years of experience. Although his methods are not always conventional, he is able to use what he describes as "little grey cells" to arrive at answers that no one else could have reached.

In his investigations, Poirot is accustomed to going to the scene of the crime after he has learned the general details of the criminal event. For example, in *The ABC Murders*, he returns to the scene of the crime at 5:30 p.m. because he "wants to reproduce as closely as possible the atmosphere of yesterday." This also speaks to his practice of uncovering the psychology of the killer. While investigating the Andover crime scene, he considers every detail, asks questions of other investigators to whom the crime was first reported, and also considers whether fingerprints were found, as the science and technology to process other types of DNA were not accessible.

In many cases, such as the one in *Murder on the Orient Express*, Poirot is the first investigator on the scene, so the body has not been touched until then. While examining the crime scene, "Poirot's eyes roamed the compartment; they were bright and sharp as a bird's; one felt that nothing could escape their scrutiny." Poirot is known for his meticulous examination of crime scenes, as he leaves no witness unquestioned and no shred of evidence overlooked. Poirot's way of uncovering evidence at crime scenes would not be considered inadmissible in a court of law. On the other hand, Agatha Christie also created *Miss Marple*, who is a very independent woman. She is an older, unmarried woman who lives in a small English village. Unlike Poirot, she has no formal detective training and uses only her natural nosy tendencies, observational skills, intuition and feminine knowledge to solve crimes.

Unlike Poirot, Miss Marple is almost never the first investigator to arrive at the scene of a crime. In fact, she sometimes has to force herself to see the crime scene, as she is not a traditional detective, although one might say this is because she is a woman. In *The Body in the Library*, when Miss Marple is told that "I'm afraid no one is allowed in", her friend responds with, "You know Miss Marple very well. It's very important that she sees the corpse". At the actual crime scene, Miss Marple doesn't seem to make many observations to share with those around her. In *A Caribbean Mystery*, Miss Marple never actually gets to see the crime scenes or the bodies associated with the victims' deaths, so this critical piece of the investigative procedure is missing for her. Instead, she contacts the coroner each time to try to reconstruct the cause of death, which is said to be the next step in the investigative procedure.

In fact, Agatha Christie's novels focus on the actual investigation of the crime, rather than the prosecution of the perpetrator to follow. In addition, there were no computers at the time of the novels. So, in this respect, both Poirot and Marple were at a disadvantage, as "conducting computer checks on suspects in a homicide increases the likelihood of their release" (Braga 2019, 343). Although it may have increased the rate of solving cases, both Poirot and Marple would have been equally successful without the use of modern technology now available to investigators to profile suspects. The next step Poirot usually takes is interviewing potential witnesses. The best example of this is The Murder on the Orient Express, in which he talks to every person who had access to the train car where the murder took place. Miss Marple uses gossip as an interviewing tool and this can be considered a substantial part of her investigative procedure. She does not use ordinary interviewing techniques as this would arouse suspicion from others.

Science and technology are almost non-existent in the investigation of the two detectives, as mentioned. Poirot occasionally makes references to dusting for fingerprints, as in *Murder on the Orient Express,* when he goes over the crime scene, specifically the window frame, blowing dust he had in his pocket over it. This is about the only scientific evidence that could immediately link a suspect to a crime scene. Miss Marple avoids the scientific route altogether, choosing to focus on the strengths that being a Victorian gives her. The closest she comes to DNA is in *The Body in the Library,* when she notes that the fingernails of the corpse in the library could not be Ruby Keene's (Monico 2021, 7). In all the novels, Poirot manages to get a confession from the perpetrator or perpetrators. With the exception of the novel Cortina, he also has witnesses to these confessions. Miss Marple, on the other hand, has shown that she is able to prove attempted first-degree murder. There have also been instances when Miss Marple has caught criminals attempting to commit another crime, as in *The Body in the Library* and *A Caribbean Mystery.*

Another eloquent example is *Sir Arthur Conan Doyle* (1859-1930) who also had considerable influence in popularizing scientific methods of crime detection through his fictional character *Sherlock Holmes* and who first applied the newly developed principles of serology, fingerprinting, firearms identification and examination of questioned documents long before their value was first recognized and accepted by real-life criminal investigators. The exploits of Detective Holmes sparked the imagination of a new generation of criminologists and criminal investigators. Even in Sir Arthur Conan Doyle's first novel - *A Study in Scarlet,* published in 1887 - we find examples of the author's extraordinary ability to describe scientific methods of detection years before they were discovered and put into practice. For the court, Holmes investigates and acknowledges the potential usefulness of *forensic serology* in the forensic field. So does *microscopic examination for blood corpuscles*. Apparently, such an examination is worthless if the stains are hours old. However, the new test introduced by this examination seems to work equally well whether the blood is old or new. If this test had been invented earlier, many people would have been punished for their crimes and would not have got away scot-free for lack of evidence, as happened until this new test was introduced.

There are many criminal cases that are still based on this scientific method. A man is suspected of a crime months after it was committed. His underwear or clothes are examined and brown stains are discovered on them. Are they blood stains, rust stains or fruit stains, or what are they? This is a question that has puzzled many experts, along with the question 'why'? Because there has been no reliable test. Now we have the Sherlock Holmes test and there will be no more difficulty (Saferstein 2011).

In conclusion, Sir Arthur Conan Doyle's legendary detective Sherlock Holmes applied many of the principles of modern forensic science long before they were widely adopted by the police. Last but not least, another landmark example, emblematic of forensic tactics and methodology, is the investigation carried out by Porphyry Petrovich, examining magistrate and crucial figure in Feodor Mikhailovich Dostoyevsky's novel *Crime and Punishment*. Dostoevsky describes Porfiri in great detail, sketching his portrait in just four sentences: "He was a man of about thirty-five, not quite medium height, full-bodied and fat, clean-shaven, without a moustache or burns, with close-cropped hair on a long, round head that stuck out quite well at the back..." Although Porfiri

Petrovich's role appears in the novel quite late (part three) and is relatively short (60 pages), it is a central one. With boundless energy, he always puts Raskolnikov - the perpetrator - in the shade. The investigator's attention to detail and his deft questioning reveals his intellect, psyche and faith. Porphyry Petrovich solves the mystery of Raskolnikov's murder and, most importantly for the novel, helps the murderer endure the torment of guilt and confession to his new life with Christ (Naumann 1972, 42). Porphyry Petrovich seems like a nice guy despite Raskolnikov's serious crime. The investigation proceeds on several levels, some seemingly insignificant, asking Raskolnicov, for example, to declare his assets (given that the murder victim owned a pawnshop) or asking him to write an essay on crime and morality. The answers provided gave Porphyry Petrovich a deep insight into Raskolnikov's character and revealed his conviction of his guilt, causing him to reconcile the psychological gap between his ideas and the deed committed; the tactics adopted also made it difficult for Raskolnikov to control and restrain himself, as he was simply thrown into an inner conflict. All this culminates in Raskolnikov's confession to the crime, urging him to "honor the gift of life by looking beyond prison" (Study Guide about *Crime and Punishment* - Dostoevsky 1866).

Forensic laboratories

Before the establishment of specialized laboratories, police in many parts of the world relied on the scientific assistance of people whose occupations enabled them to provide the necessary expertise. In the absence of a centralized system, it was a problem to know who to turn to, which initially led to the formation of formalized institutions, which were almost invariably set up as parts of universities or hospitals. As they became limited over time to examining and providing expertise in a limited number of forensic disciplines, police forces took the step of developing *their own forensic laboratories.* These labs dealt with the examination of physical, material evidence relating to the circumstances of the crimes, the victims and the perpetrators. Forensic findings made in a laboratory were and are used together with other forensic science and criminal investigation findings to prepare evidence for a court proceeding or trial.

Europe took the lead in this development, with the first police forensic laboratory being opened in 1910 in Lyon, France, following the initiative of Edmond Locard, referred to above. Following his model, police laboratories subsequently appeared in Germany (Dresden, 1915), Austria (Vienna, 1923) and other countries, including the Netherlands, Finland and Sweden, the last three of which became operational in 1925.

This transition to forensic laboratories did not occur in the United States of America (USA) until 1923, when the Los Angeles Police Department established its own forensic laboratory. Failure to obtain an indictment in a case due to improper handling of evidence prior to laboratory examination was the reason for this change. Many other police departments in America followed suit, with the Federal Bureau of Investigation (FBI) laboratory opening in 1932 (White 2004).

Conclusions

In conclusion, forensic science has evolved in a way that has been closely linked to the progress of science, and to speak today of improving methods and techniques in such a science is not possible without knowing their evolution. This is all the more necessary given that today's threats are increasingly complex and atypical, which requires a high capacity for adaptation and rapid reaction on the part of criminologists too.

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