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One hundred years of forensic sciences in Quebec: the evolution of scientific techniques since 1914

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Abstract

In 2014, Quebec's forensic science laboratory (*Laboratoire de sciences judiciaires et de medicine légale*) is celebrating its 100th anniversary. Since its foundation by Dr. Derome in 1914, scientific techniques in the various areas of forensic science have greatly evolved. Not only was the Laboratory the first forensic science institution in North America, it has been a pioneer for several analytical methods. The early days of the Laboratory as well as the specific evolution of the departments and divisions of biology, chemistry, arson and explosion, questioned documents, forensic pathology, odontology and anthropology, toxicology and administration will be reviewed here.

KEYWORDS:

Forensic sciences; forensic toxicology; forensic pathology; forensic chemistry; ballistics; document examination

1 | INTRODUCTION

The Ministry of Public Security of Quebec can be proud of its involvement in the founding of the first laboratory of forensic science in North America. This institution, created in 1914 by Dr. Wilfrid Derome, is celebrating its 100th anniversary this year. The following will attempt to depict the important events related to a century of forensic history.

Wilfrid Derome was born of farmer parents in Napierville in 1877. He completed his classical studies at the Collège de Joliette where he performed with great merit. He went on to medical studies at the University of Laval in Montreal where he graduated Summa Cum Laude in July 1902. He then went from an intern position at Notre Dame Hospital to a histology demonstrator position in the Faculty of Medicine, and then a director position in the Laboratory of Pathology and Histology of Notre Dame Hospital. By that time, the General Prosecutor's Office had already asked Dr. Derome, like many fellow physicians and surgeons, to demonstrate his expertise in court. For Dr. Derome, the walk was very short since the Court of Montreal was just across the street from the hospital. The blatant lack of training of his fellow expert witnesses, as well as his own, compelled Dr. Derome to undertake a specialization in forensic medicine, which he completed at the University of Paris with the famous Victor Balthazar from 1908 to 1910. He returned from the City of Lights with a specific forensic expertise enlightened by a solid knowledge in ballistics, criminal psychology as well as fingerprints. For the next three years, Dr. Derome attempted to convince the government of the need for a reorganization of the forensics system in the province of Quebec. The Medical Society of Montreal represented Dr. Derome's first step forward in this quest, as they admitted that physicians did not have adequate training to support their testimony in court, which could lead to serious miscarriages of justice for which they did not want to be held accountable. Soon after, the College of Physicians and Surgeons of the Province of Quebec also asked for a legislative amendment dictating the need for a commission of experts able to decide on some disputed medical facts presented in court. Finally, the Montreal Bar stressed that a forensic expert would be of great assistance in criminal matters. All this bureaucratic pressure, along with a media awareness campaign, resulted in the announcement of the foundation of the first North American Forensic Laboratory by Quebec Prime Minister Sir Lomer Gouin in December 1913. The only existing forensic laboratories at that time were located in Paris (Institute of Forensic Medicine – 1868) and Lyon (Lyon Laboratory – 1910).

Following the signing of a 5-year lease with the mortician H. Bougie Ltd., the Forensic Science Laboratory settled in at 179 Craig Street in Montreal for the modest sum of $900 per year. In addition to the funeral home, the Laboratory shared the building with the Coroner's office and the Investigations Court. Dr. Derome was then appointed director and allocated an amount of $2,500 for the organization of the Laboratory. Although delayed by the war, the installation work was completed by July 1914 with significantly higher costs than initially budgeted ($5,573). Dr. Derome was then the only physician licensed to conduct analyses on behalf of the provincial government. Despite an excessively loaded schedule, he found time to be a member of the Society of Forensic Medicine of France and of the International Association for Identification. He also managed to publish several scientific papers. Meanwhile, the analyses he performed in the Laboratory varied broadly. For example, during autopsies, Dr. Derome used probes to measure the angle and depth of gunshot wounds. He would then perform the ballistics tests, which took place partly in the shooting range in the basement. He collected the bullets in yellow pine planks 2 cm thick, rolled them on carbon paper or tin foil and onto a white sheet to finally photograph and enlarge the traces left by the characteristic striations on the blank page. Several toxicological analyses were also needed. Characterization of lead was carried out using hydrogen sulfide, potassium chromate and sulfuric acid, while for the analysis of morphine, the stomach content was first extracted by the Stas-Ogier method and then characterized by ferric chloride and Froede reagents. In one particular instance, Dr. Derome even had dogs ingest strychnine to prove a case of poisoning.

In 1920, it was obvious that Dr. Derome could not satisfy the demand for his work, so Franchère Pépin, who had just graduated from the Faculty of Pharmacy of the University of Montreal, joined the lab as an assistant chemist expert in toxicology, poisons and explosives. The development of a toxicological division to the Laboratory was another North American first. Hiring an assistant allowed Dr. Derome to publish a book entitled Handbook of Forensic Medicine, which reinforced his reputation as a renowned expert. In 1922, Dr. Rosario Fontaine also joined the Laboratory as assistant director. Dr. Fontaine studied in Paris at Dr. Derome's request and specialized in document analysis. Both experts gained solid experience as expert witnesses in court. A photographer was also added to the team, since according to Dr. Derome, defining a body's positioning, the condition of the clothes after the murder and the nature of the surrounding objects were all essential. Finally, a technician was hired to perform various laboratory tasks at the request of the experts.

With time and addition of personnel, office space became cramped and the ageing condition of the building rendered decent hygienic conditions almost impossible to maintain. In December 1923, the Premier Taschereau approved the relocation of the Laboratory to 443 St. Vincent Street in Old Montreal. The premises were certainly bigger, but much less modern than had Dr. Derome wished. In addition, the Laboratory had to share the building with the Provincial Police, the Coroner's Office and the morgue. Although the laboratory was not as new and tidy as they would have hoped, Dr. Derome and his team diligently continued producing rigorous expertise. Accordingly, they were constantly on the lookout for technological and scientific advances in the field. In the mid-1920s, Dr. Derome implemented an inmate identification method based on the Bertillon system, which required the classification of data sheets annotated with photographs, fingerprints and committed crime for each prisoner. Dr. Derome was responsible for this "Identification Bureau" and had to provide a copy of each record to the Federal Ministry of Justice. Many said at the time that Dr. Derome had established the finest forensic identification system in America. The hard work of Dr. Derome and his team did not stop there and in 1926, the Laboratory acquired a microspherometer, which was manufactured under the instructions of Dr. Derome himself and used to observe marked projectiles. This acquisition was followed by the publication, in 1929, of *L'expertise en armes à feu*, firearms expertise, that was admired worldwide both for its clarity and its completeness. With the improvement of forensics always in mind, Dr. Derome also published *Le lieu du crime*, the scene of the crime, a collection of memos addressed to the police corps across the province that explained the conduct one should have when in charge of a crime scene.

Around that time, forensic laboratories started developing across North America. Accordingly, the Attorney General's Forensic Laboratory of Ontario was created in 1932 and the first forensic laboratory of the Royal Canadian Mounted Police (RCMP) opened in Regina in 1937. It was also at that time that J. Edgar Hoover visited the Laboratory seeking inspiration for the future laboratory of the Federal Bureau of Investigation (FBI) which then led a crucial battle against organized crime. It goes without saying that the reputation of Dr. Derome transcended borders. He was called to testify across Canada. Some demands even led him to British Columbia at the request of the attorney general in order to conduct ballistics tests in a double homicide case. Several American police bodies, such as Detroit, Chicago, St. Louis and Los Angeles tried to recruit Dr. Derome at one point or another. The good doctor remained firmly attached to the Montreal facility, although he took pride and pleasure in educating his peers through teachings and seminars.

At that time, the Laboratory expertise started to be involved in many publicized cases. For example, in the case of Aurore, the child martyr, Dr. Derome was called to pronounce himself on the mental health of the mother, who was subsequently sentenced to death for the murder of her daughter. In another case, father Adelard Delorme was accused of coldly murdering his brother Raoul. This case was rendered famous for its ballistics evidence, demonstrated using large format bullet cardboard models. This was the first evidence of its kind to be presented in this country. Not to mention the Morel case, also known as the holdup of the Hochelaga Bank, where a former police detective from Montreal, Louis Morel, robbed a bank's truck and stole $140,000. Evidence leading to the hanging of Louis Morel and his accomplices was supported by fingerprint analysis and examination of a mask found in the getaway car.

At the age of 54 years old, on 24 November 1931, Dr. Derome died of cancer at Notre Dame Hospital. He left behind an immeasurable legacy to forensic science in Quebec as well as the maxim that every Laboratory employee strives to meet even today: "Refrain from assertions you cannot prove". He bequeathed the responsibility of the Laboratory to Dr. Rosario Fontaine, his colleague and friend, who ensured the administrative management of the Laboratory. Before his death, Dr. Derome also ensured the scientific continuation of the Laboratory, by sending Jean-Marie Roussel, MD graduate from the University of Montreal, in France to study forensic sciences. Dr. Roussel took the Laboratory assistant director position upon his return. Drs Fontaine and Roussel invested their time and efforts to continuously strive for excellence as they were taught by Dr. Derome. Dr. Fontaine, following his predecessor's footsteps, took part in the investigation of several major crimes of his era, such as the Laurier Palace Theatre fire where 78 children died trapped on a staircase. He also published his fair share of scientific articles; as an example see the case of a 17-year old boy struck by lightning whose torso, arms and legs bore the hallmarks of a fern, printed on his flesh by a phenomenon called "electric photography". Also, in order to broaden the skills of the Laboratory, Dr. Roussel visited the New York police department Laboratory in 1939, where he learned a new technique for blood differentiation.

Over the years, Drs Roussel and Fontaine added highly qualified scientists to the Laboratory team to meet the demand for the laboratory's work while continuously providing quality services. Dr. Bernard Péclet joined the team in 1947 as an assistant chemist and Dr. Jean-Paul Valcourt in 1955 as a Laboratory pathologist. In 1953, Dr. Roussel was invited to a meeting organized by various Canadian colleagues, which led to the creation of the Canadian Society of Forensic Science (CSFS). The first congress of the CSFS was held at the University of Montreal in 1954 under the supervision of Drs Roussel and Fontaine. From 1956 to 1963, the number of cases assigned to what was called the Laboratory of Scientific Police and Forensic Medicine at that time increased from 893 to 1450.

Given its age and layout, the former hotel that housed the Laboratory was inadequate for all the required expertise to be carried out. Additionally, the staff numbers were insufficient especially when compared with the Ontario forensics laboratory that employed 54 persons at that time whereas Quebec only had 18 for a similar amount of work. Dr. Péclet stressed these facts to the Ministry's highest levels and, upon his request, the Ministry set up a large research project that aimed at the creation of a building housing the headquarters of the Provincial Police, the Laboratory, the Coroner's Office and the Prevention Centre. Representatives of the Laboratory were sent to several institutions at the forefront of technology, such as the offices of the Chief Medical Examiner in New York or the Detroit Court House, to set up a cutting-edge laboratory. It was in 1968 that the equipment and staff of 443 St. Vincent moved to the fifth floor of the brand new building located at 1701 Parthenais. At that time, Dr. Fontaine had taken a well deserved retirement, although he still testified as an expert witness in documents analysis when needed. Dr. Roussel had taken over as director of the Laboratory and remained there until 1972, when, in turn, Dr. Péclet became director. The 1970s led to increased specialization of the scientists and to the creation of different sections within the Laboratory. Also, in 1978, the institution was divided into two separate administrative units, the Scientific Police Laboratory headed by Dr. Péclet and the Laboratory of Forensic Medicine, led by Dr. Valcourt.

2 | BIOLOGY SECTION

Undoubtedly, biology is the section that underwent the fastest growth in the last 60 years.

Before 1965, blood type analysis (ABO typing) was performed by a haematologist at Rosemont hospital. Dr. Roussel, then head of the Laboratory, appointed the biologist Pierre Boulanger to form a new Biology Section. Although the Laboratory was a pioneer in forensic sciences in North America, research and development had been put aside for a number of years due to the lack of personnel. In 1965, Pierre Boulanger turned to the FBI as well as Toronto and Ottawa's laboratories for inspiration. The new techniques he gleaned from his counterparts eventually allowed blood, sperm, hair and fibre analysis.

In the early days of the Biology Section, ABO typing was the sole analysis performed. Several other analyses were added to complement the blood profile: esterase D, PGM and EAP. These are all polymorphic proteins, meaning they can take different forms from one individual to another, so as a group they are characteristic of one person. In 1970, the Biology Section was analyzing about 1,500 cases per year. Around the same time, the Laboratory initiated an innovative Sexual Assault Kit project. These kits gave tools to first responders (policemen, doctors, nurses) for taking samples that would then be analyzed by the Laboratory. Expertise in blood spatter analysis was also developed in the same years.

The biologist Léo Lavergne was hired in 1989 to develop and validate a DNA analysis method. This technique was to replace ABO typing and polymorphic protein analysis. Although the Laboratory's administration wanted to develop this method, the provincial government's budget did not allow such spending. A year and a half were therefore necessary to set up the DNA analysis laboratory.

The first generation of DNA analysis techniques was restriction fragment length polymorphism (RFLP). In this analysis, DNA is cut in pieces using different restriction enzymes. The lengths of DNA segments vary from one person to another due to the presence of polymorphisms. Pieces of DNA are then separated according to their length using gel electrophoresis. Finally, the position of the fragments in the gel is revealed using a radioactive probe. 1 μg of pure DNA was necessary to carry out this analysis; therefore only large blood spots could be analyzed. Analysis time was one week. About 70 to 90 cases per year were analyzed the first few years. A small database with the results of molecular weights for five loci (DNA sites) was even created. This was a very innovative project for the time. Comparison of different profiles using this database found several matches. In 1995, the original radioactive probe was replaced by a chemiluminescent probe. Sensitivity thus became 0.5 μg of DNA and analysis time decreased to one day.

Obviously, this kind of evidence was new for courts. The basic principles of DNA had to be clearly explained and the first testimonies lasted several days. However, no strong opposition of the technique occurred here like it did in the United States. The C-107 bill was adopted in 1995. It allowed the issuing of warrants for DNA collection under presentation of adequate proof by the police officers. This was previously contested under the right of an individual not to incriminate himself. This bill also ordered the creation of the National DNA Databank and the Convicted Offenders Index (COI). The National DNA Databank was implemented in June 2000. At this time, it received 800 to 1,000 files per year. Today, 6,000 files per year are submitted. The early years gave rise to relatively few matches given the small number of profiles constituting it. In 2014, four to five matches per working day are brought to the attention of forensic biologists. The efficiency of the technique used, coupled with the number of positive matches obtained with the National DNA Databank are partly responsible for the striking growth of this area of forensic sciences.

In 1998, the DNA analysis technique was switched from RFLP to PCR-STR (polymerase chain reaction – short tandem repeats). In this new method, DNA sites containing repeated patterns of two to ten nucleotides are analyzed. These sections are called short tandem repeats. The number of pattern repetitions varies from one individual to another. By analyzing several sites, each containing different patterns present in a variable number from one individual to another, a DNA profile is created. The switch from DNA fragments created by restriction enzymes to short tandem repeats was necessary to use the amplification by polymerase chain reaction. This technique uses the enzyme DNA polymerase to produce thousands of copies of targeted DNA sites. Since copied regions cannot be more than about 2000 nucleotides long, RFLP fragments were too long to be used. PCR allows a much higher sensitivity: nanograms of DNA can now be detected. Since this technique was already known since

1995, forensic biologists have been anticipating this conversion. The original STR method used nine short tandem repeat sites. This number went up to 13 in 2002, then to 15 and will soon be 21 or 23 short tandem repeats depending on the commercial analysis kit that will be selected. This evolution is necessary to better analyze DNA mixtures and avoid incorrect matches.

Soon after the introduction of this new DNA analysis technique a project for computerization of operations was started in 2001. Then, in 2003, Diane Séguin led the project for analyses automation. The validation of this robotic platform was completed only in 2005. This instrument had not been designed for forensic DNA analysis, but rather for general pipetting tasks. Therefore, the biggest challenge was to avoid contamination. Adjustment of pipetted volumes, positions of containers, height of the pipet tips and other parameters allowed a contamination-free analysis to be performed. About 10 platforms are currently active in the Biology Section, performing various tasks in genetic analysis.

In the last few years, the Laboratory has developed a specialization in interpretation of analysis results from DNA mixtures and their comparison with databanks. This technical skill was becoming increasingly necessary, since improved analysis sensitivity allowed detection of more mixtures. In early 2000, profiles with more than two individuals were considered unanalyzable. Nowadays, the amplification technique is so reproducible that it is possible to compare the intensity of signals measured and to attribute them to one of the individuals composing the profile. This allows analysis of more complex samples. However, interpretation of such results is more time consuming.

Electronic archiving is one of the latest additions to the Biology Section. All the personnel had to adjust quickly to a number of changes, including a rapid evolution of technologies. The team grew from three to 62 people since 1965. There are a great number of technological developments and this pushes the Biology Section to continually evaluate these new technologies to stay up to date.

Since 2010, the FBI initiated the development of Rapid DNA. Four to five samples can be analyzed in 90 minutes with this technology. It is mostly targeted for the treatment of swabs obtained from suspects under arrest. Use of Rapid DNA for this purpose in Canada would require new legislation. If this occurs, there would be great implications for the Laboratory. Crime scene analyses would be another target for this technique. This could help to guide sampling. For example, the blood spatter of the suspect and the victim could be differentiated at the crime scene and sampling performed accordingly. However, the technique will need to be more robust and compact for this use.

Discussions about single nucleotide polymorphisms (SNPs) analysis have been going on since 1999. This would allow an image of the suspect to be drawn from DNA analysis (eye colour, hair colour, etc.). Fifteen years later, it seems like this technology is more stable and a number of kits are now commercialized. This kind of analysis is therefore closer than ever.

Statistical analysis and degraded DNA analysis should also evolve in the next few years. Degraded DNA analysis has been available for three years and allows results to be obtained from cases where DNA samples have been stored in conditions of high humidity or temperature. All things considered, forensic biology has changed so much in the last 20 years that it is hard to predict the future with any degree of certainty.

3 | CRIMINALISTICS SECTION

Today, the Criminalistics Section of the Laboratory includes the Ballistics, Chemistry, Arson and Explosives and Questioned Documents divisions. Each division comprises several specialized scientists accompanied by a technical and administrative support team. All new criminalistics specialists must follow a two-year training program before they are qualified.

3.1 | Ballistics Division

In the Ballistics Division, six experts are working on case files related to firearms or tool marks and footprints. The Division mainly resolves cases of illegal possession of firearms, breaking and entering, illegal hunting, suicide and murder. In order to do so, experts check if the seized weapons are functional, compare bullets and casings recovered at the scene with those fired by the weapons received by the Laboratory. Sometimes, they even reconstruct crime scenes. The essence of the discipline has hardly changed since the days of Dr. Derome. As such, the basis of the work is to microscopically observe a projectile or a casing and verify the presence of characteristic striations to establish a correlation with a specific firearm. Of course, the instrumentation has evolved over time and the shooting range of 179 Craig Street has turned into a secure room with fire walls made of steel and Kevlar while a custom tank filled with water has now replaced the pine boards. The main changes to the instrumentation were made to improve the ergonomics of the microscopes rather than to improve the optics, since these have been sufficient for decades. On the other hand, the advent of computers has opened a world of possibilities.

As such, in the mid-1990s, the Division worked with Forensic Technology, a ballistics development company, on an Integrated Ballistics Identification System (IBIS). Nowadays, this system combines an optical system at the forefront of technology that allows for 3D expertise along with a powerful matching algorithm that enables the comparison of data stored in several databanks across North America. Despite these impressive technological advances, the safest way to positively match a bullet with a firearm remains microscopic observation by the expert. This is why, for most cases, projectiles or casings are still manually compared against local unresolved files from the past three years. Obviously, the volume of cases treated in the Laboratory is very different from that of the United States, which still allows this kind of analysis on our side of the border. Comparison with older or foreign files is solely done using IBIS, which also serves as a tool for manual match confirmation.

Recently, the Division acquired a high-speed camera that can record more than 20,000 frames per second. This tool is used to illustrate several particular cases in court and can also be used to explain the behaviour of projectiles in certain situations (ricochet on different surfaces, wall perforation, etc.). Other tools are available today to determine the trajectory of a projectile in the analysis of a crime scene and a laser pointer is often used as such. When analyzing marks or footprints, experts mainly use the microscope to match tool marks that were left on a surface to the tool itself. In this case, the work is especially time-consuming since the area to be examined can be much larger than in the case of a projectile.

In the early 1990s, the Division had its own ballistics photographer who mainly illustrated tool marks and footprints and whose Polaroids were produced before a jury more than once. The advent of digital technology made the task easier and illustration work is now either done by the specialist himself or in collaboration with the Imaging Division. The number of tool marks and footprint files treated has declined steadily since the late 1990s, a period that coincides with an orientation change for the Laboratory. At that time, the administration estimated that the costs associated with staff working on crime scenes were too high. From that moment on, the experts had to examine crime scenes only during normal operating hours. In consequence to this management reorganization, the various police forces had to restructure and many of them developed their own expertise analyzing crime scenes. This rearrangement drastically reduced the number of scenes analyzed by the Laboratory's experts in all fields of expertise. To this day, the Laboratory still examines some crime scenes, especially more difficult cases in ballistics, arson and explosives, blood spatter analysis or pathology (murders or mass casualties).

The Ballistics Division processes approximately 1,800 to 2,000 cases annually. Projections suggest that this number will remain constant for years to come. Obviously, the work of specialists requires that they are always on the look-out for technological advances. In ballistics, this translates into the creation of a project studying the need and applications of an unmanned aerial vehicle (UAV) photographing the crime scene in full before it is contaminated by any human presence. The Division's experts also participate in various conferences on the subject, including the famous AFTE (Association of Firearm and Toolmark Examiner) conference.

3.2 | Chemistry Division

Forensic chemists handle trace analysis, whether it is paint, polymers, glass or fibres. They seek to connect different pieces of evidence that are sent in by the police. For example, they can compare the residues found on the clothing of a victim of a hit and run with the particles found on the bumper of the suspect's vehicle, or look for a correlation between glass particulates on the clothes of a thief with the smashed window of a breaking and entering case. Already, in the early 1990s, the Chemistry Division regularly used a pyrolyzer-mass spectrometer device to identify paints and polymers – a rather rare apparatus for that time. This technique requires only a small amount of sample, which makes it very useful for trace analysis. Accordingly, the pyrolyzer-mass spectrometer is still used today although the unit has progressed in terms of automation, robustness and sensitivity. During the same period, Fourier transform infrared spectroscopy (FTIR) appeared in the Laboratory. The spectrum obtained by Fourier transform is used to identify different materials, comparing the unknown with a database or to confirm the correlation between two different pieces of evidence. At the same time, the Glass Refractive Index Measurement (GRIM) started to develop. One of the chemists had refined this new technology which aims at measuring the refractive index of a piece of glass precisely through a temperature variation of a reference sample. Although still used, GRIM proved to be a not very discriminating technique. In addition, a pilot project for the comparison of glass using X-ray microfluorescence is now being developed in the Laboratory. The arrival of Raman spectroscopy in the late 2000s improved trace analysis as this technique is used to characterize the molecular composition of a sample. The technique is non-destructive and uses a very small amount of sample. As such, it is possible to investigate the properties of only a few square micrometres of sample.

Fibre analysis appeared in the mid-1980s in the Chemistry Division of the Laboratory, and is an area that was previously managed by the Biology Department. A toxicologist was given the mandate to update the expertise of the Laboratory in this matter. He got involved in the analysis of dyes, tears and breaks in fibres as well as the melting points of different materials. Nowadays, microscopy is still the key to a successful fibre analysis, which enables, for example, the observation of the forms of the fibre or the presence of a delustring agent. The birefringence is also recorded as a microscopic technique for identifying the different materials of which the fibres are made. Subsequently, FTIR spectroscopy confirms the nature of the fibres, although nowadays Raman spectroscopy is slowly replacing FTIR as a technique of choice. The micro spectrophotometer certifies the colour of the fibre previously estimated with the naked eye or the microscope. Measuring the melting point of the fibres was a technique used in the first years of the pyrolyzer–MS, since the instrument was not suitable for fibre analysis given the low throughput of the instrument before automation. This technique allowed the distinction between different but similar fibres such as nylon-6 and nylon-9.

The Chemistry Division handles an average of 350 to 400 cases per year and the forecasts suggest that demand will remain stable for years to come, similar to the other divisions of the Criminalistics Department. The four experts and technical staff of the Division make sure they stay up to date, in part by attending conferences such as the AAFS's (American Academy of Forensic Sciences) annual meeting.

3.3 | Arson and Explosions Division

The need for an explosives specialist arose very early in the history of the Laboratory. The 1949 Sault-au-Cochon tragedy sent Dr. Roussel and his new partner Bernard Péclet looking for traces of explosives in the debris of a plane crash. This unfortunate event, the first and most important plane crash due to a criminal act in Quebec history, was caused by a love triangle that resulted in the death of 23 passengers due to the explosion of a bomb in an airliner. The two colleagues were fortunate enough that the flight was delayed and the explosion took place above land and not above the St. Lawrence River as planned. This delay allowed the team to recover what looked like a firing mechanism as well as traces of dynamite.

The 1970s led to an increased specialization of the Laboratory scientists, which allowed the hiring of a specialist who studied explosions and characterized explosives, mainly dynamite. This remained a one-man Division for many years, as the demand for such expertise was very low. The presence of several construction sites and mines in Quebec gave the province a special status in the field of explosives. Indeed, the accessibility of blasting products made smuggling and illegal use of explosives a rather common phenomenon. Moreover, the mid-1980s saw the emergence on the market of a new type of explosive: the emulsion. The emulsion consists of a cartridged discontinuous aqueous phase in the form of a droplet of inorganic oxidizer salt such as sodium nitrate or ammonium nitrate, a continuous organic phase composed of a dye and a paraffin medium containing the aqueous droplets and a uniformly dispersed gas phase, which allows better contact when primed. The analysis of this type of explosive required the intervention of a chemist to separate and identify these different phases. Some techniques such as solid phase extraction followed by analysis of the extracts by gas chromatography-mass spectrometry (GC-MS) or gas chromatography at high temperature-flame ionization detection (GC-HT-FID) or X-ray diffraction were used.

Then came the biker war in Quebec: a very busy period for the Explosion Department that began in the mid-1990s and stretched until the early 2000s. Different organized crime groups fought violently for the control of illegal drug trafficking and this confrontation involved numerous explosions and arsons in different institutions of the province. The increase in case number pushed the Laboratory to hire a second expert in the Arson and Explosions Division. This event helped the scientists improve their knowledge of firing mechanisms, the modus operandi of bikers being characterized by the use of a gear box connected to a remote-controlled bomb placed under a vehicle. Then, as the biker war came to an end, the arrival of the internet gave all amateur chemists the recipes used by terrorists to manufacture home-made explosives. Although a marginal phenomenon, the synthesis and use of certain peroxides such as acetone triperoxyde of tricycloacetone (TATP) or hexamethylene triperoxide diamine (HMTD) is a reality that must be taken with the utmost seriousness. As such, the Division is still composed of two specialists who must stay on the lookout for different recipes available on the web that could be used for illegal purposes. These compounds are then synthesized in the Laboratory and experts evaluate the best possible identification method for each of them. The tools available for chemists are either X-ray diffraction, which allows for identification of the crystal structure of various inorganic compounds, or X-ray microfluorescence, which allows for an elemental analysis of the samples. The arrival of an ion chromatograph this year will bring an additional dimension to the analysis of cation and anion characteristics of explosives, particularly in the case of post-blast residues. The Explosions Division handles about 30 cases a year, many of which are simply connected to an offence under the Explosives Act, which dictates strict conditions of storage, possession and transport of explosives. Each year, some cases are connected to more serious incidents. Obviously, explosives experts need to be on the lookout for any advances in the field and must be ready in the unlikely event of a terrorist incident or other major event. The low number of cases handled by the explosives experts yearly does not justify the employment of two full-time specialists; therefore, they are also in charge of the Arson Division of the Laboratory.

The Arson Division analyzes more than 500 cases per year. Detecting the presence of an accelerant in different exhibits constitutes the essence of the work. There was a time when the Laboratory was intensely involved in the analysis of fire scenes. At that time, there were three specialists working almost full-time on different crime scenes. They left the task of detecting accelerants in the evidence they collected to the laboratory technician. The detection of flammable liquids was then performed by steam distillation, a technique that allowed the separation of volatile compounds contained in the sample with water vapour. In the late 1990s, organizational changes gave a new direction to the Division. Chemists were now expected to focus on the analysis of evidence. The arrival of activated charcoal on the market allowed extraction techniques to change for a faster, more functional and more sensitive analysis. The detection method of choice was, and still, is the GC-MS, since it is very efficient in separating and detecting aromatics and alkanes, the main components of flammable liquid compounds. Another aspect of the work of an expert in the Arson Division of the Laboratory is the examination of other, auxiliary evidence potentially involved in arson. Often, the experts have to consider gas appliances, wall heaters, stoves, electric circuits, and sometimes charred debris to determine if these items could be the cause of the fire in question. This work requires extensive electrical and fire science knowledge. As in all other areas of forensics, future challenges consist of the constant improvement of analytical techniques and updating knowledge to help provide the best possible services to the Laboratory's customers.

3.4 | Questioned Documents Division

Before the Laboratory's move to its new premises on Parthenais Street in 1967, there had not been any Questioned Documents Division; although a few cases were treated by Dr. Fontaine.

In order to correct this situation, Dr. Roussel asked André Münch, a young graduate of the *Institut de police scientifique et de criminologie de l'Université de Lausanne*, to create from scratch a division responsible for comparative handwriting analyses and document examinations. He arrived in August 1970 and immediately went to work on this task. Barely a few months later, the October Crisis broke out. Because of the quantity of documents to analyze, Dr. Roussel hired a contract specialist, Michèle Langlois, who had just returned from two years of training at the *Laboratoire inter-régional de police scientifique de Marseille*. The Questioned Documents Division was up and running.

During the 1970s, the different police departments of the province put a lot of effort into fighting economic crime and fraud, a battle that resulted in the need to analyze many types of documents (cheques, contracts, receipts, account books, etc.). This greatly increased the demand for services. It was therefore decided fairly early to use contract employees (in Montreal and Quebec City) as well as the RCMP and its Questioned Documents Division in Montreal. Later on, extra personnel were hired by the Laboratory, in order to develop and maintain expertise internally; thus, the end of the decade also marked the end of using contract employees. It is also at this time that a new technology arrived in the division: the ESDA (ElecroStatic Detection

Apparatus) complemented incident light for the detection and reading of indented writings (latent writings in the form of noninked grooves). Later on, the 1980s were years of stability with respect to personnel and analytical techniques.

On the other hand, the decade of the 1990s was marked by many changes affecting both the Laboratory and the Division. First of all, there was the nomination of a new Director, who in turn nominated managers for various divisions, including Questioned Documents. In addition, the RCMP closed its Questioned Documents Division and the Laboratory had to absorb a portion of the cases that were handled there; new specialists were hired to enable the Division to respond to this demand. Technology was changing: VSC (Video Spectral Comparator) type devices improved the capacity to differentiate inks and papers; in the case of handwriting analysis, better microscopes allowed for more precision in the visualization and photography of the elements to be evaluated; this improved the quality of material with which the specialist worked at recognizing and comparing the graphical forms at hand.

At the end of the 1990s and the beginning of the 2000s, there was again an increase in demand, compounded by the departures of a number of employees. The Division reacted by hiring and training new personnel; the training, formalized and documented, is demanding and takes place over a full two-year period. During this period, Division personnel also became sporadically involved, depending on their availability, with various Laboratory projects: for example, setting up court testimony training for all Laboratory employees, obtaining ISO certification in the Division but also Laboratory-wide, sitting on various committees set up by management (library, scientific development, etc.). During the same period, the increased use of computers facilitated the documentation of analyses as well as report and case management, and presentations to the courts.

The 2000s also saw an evolution in the types of cases. Many small-scale economic offences were not investigated or prosecuted anymore (for example, use of stolen credit cards or falsification of welfare documents) whereas large-scale cases were appearing (for example, investigations into organized crime or massive fraud, the UPAC – *Unité Permanente Anti-Corruption*, etc.). The Division was also invited to participate in the activities of the TPIR – International Tribunal for Rwanda. The almost complete disappearance of typewriters, replaced by photocopiers and printers, modified the number and content of document analysis cases. Furthermore, it had been noted that a large number of investigators were not aware of the services available from the Questioned Documents Division; many were not even aware of the Division's existence. The Division therefore had to act on more than one level. First of all it made sure to inform the various police departments, on a continuous basis, of the services available, through meetings on their premises. The other possible clienteles, for example government ministries and organisations that manage large quantities of documents and writings, were not forgotten: there were information sessions, but also lectures given at Montreal, McGill and Laval universities as well as *Université du Quebec à Trois-Rivières*. The Division would also use these information sessions to identify and propose other niches where its expertise could be considered; amongst other tasks, the recovery of signature-related computer data (this is starting to be dealt with by groups working on digital imaging).

An important change in mission also occurred at the end of the 2000s. Beginning with the transformation of the Laboratory into an autonomous service unit in October 1996, the specialists' time had been divided between criminal cases, submitted by the various provincial police departments and considered as priorities (since they constitute the primary mandate of the Laboratory), and private or civil cases, submitted by individuals, notaries, lawyers (for example, homologation of wills). Work on civil cases had to be done without slowing down the work on criminal cases and the specialists' time was billed to the clients, allowing the Laboratory to diversify its sources of revenue. However, managing priorities was not always a simple task since the needs of the different types of clients were not the same (for example, with respect to the court delays). In order to reduce the delays in treating criminal cases, it was decided to concentrate on the latter; the Laboratory therefore decided in 2010 not to accept any more civil cases.

The evolution of technology also affected the practice of the discipline, particularly with respect to the documents portion, where technology evolves much more rapidly, leading to new possibilities for forgery as well as new security characteristics. Furthermore, although the arrival of computers has not yet initiated the onset of a paper-free society and even though there are still a very large number of paper documents (old or new) in circulation, the practice of handwriting is decreasing. Specialists must therefore continuously keep their knowledge base up-to-date. In the case of comparative handwriting analysis, a number of computerized handwriting recognition software packages have been created in the last ten years, some being used for specific tasks by the postal and immigration services. These software packages are not yet ready to replace the specialist's observations (in a large part because of the difficulty in describing numerically – and with sufficient precision – the myriad graphic details present in writings and signatures); they will probably never be able to do so, for this same reason, but they are support tools whose development specialists will have to take into account in the future.

Since 2013, the Questioned Documents Division has been stable; the four professionals in the Division respond to a constant demand of approximately 150 cases per year, in addition to their other activities (university lectures, training of investigators, training of new specialists in court testimony, ISO audits, etc.). Two elements are important for their practice: development and follow-up on standards, with respect to training and analytical techniques specific to the discipline (such as those issued by ASTM and taken over in 2012 by the SWGDOC – Scientific Working Group for Forensic Document Examination) and certification of the Division's specialists by the ABFDE (American Board of Forensic Document Examination). In the long term, the division must also be involved in research and development efforts, in order to participate in the strengthening of the scientific bases of the discipline.

4 | TOXICOLOGY AND FORENSIC PATHOLOGY SECTION

4.1 | Forensic Pathology Division

The role of the forensic pathologist has greatly evolved since the creation of the Laboratory. It went from the super forensic pathologist performing all types of analyses to the specialized medical doctor. However, the pathologist remains the focal point of suspicious death inquiries, performing autopsies, ordering analyses from other sections and compiling all the results in order to determine cause of death.

Over the last 25 years, there were no radical changes in the forensic pathology practice. Dissection techniques and anatomical knowledge essentially stayed the same. However, new diagnostic tools appeared that complicated cases. For example, the appearance of DNA analysis in homicide cases increased the number of samples taken during the autopsy. Toxicological analysis also evolved, allowing more precise identification of xenobiotic intoxications and metabolic disorders such as hyperglycaemia. Therefore, pathologists need to keep their knowledge up to date regarding the available analyses. They have also been required to follow the emergence of new weapons and their observable evidence during the autopsy. This was the case with the electrical impulsion gun (Taser), which appeared in the mid-1970s. Computerization also brought a vast modification of work habits, amongst others for report redaction, numeric imaging and radiology. Additionally, there was a specialization movement in pathology. Forensic pathologists are now more frequently consulting specialized hospital neuropathologists or cardiopathologists.

Preparation of histological slides became automated in the early 1990s with the introduction of a cover slip and automated slide colouration. However, the colourations used stayed pretty much the same. An important novelty in this area was the introduction of immunohistochemistry, invented in 1941 but arriving in the pathology laboratories around 1990. In immuneohistochemistry, specific proteins (antigens) are targeted by applying an antibody that will bind to this protein. The localization of the antigen-antibody couple is revealed by a chromogen, which will react with the antigen-antibody couple and create colouration or fluorescence. This technique is used amongst others in the diagnostics of cancer and shaken baby syndrome.

A modernized bill on the research of cause and circumstances of death was introduced in 1986. This law does not govern the Laboratory directly, but pathologists must take it into account when organizing their work. Indeed, coroners are responsible for ordering an autopsy at the Laboratory. In 1991, the Scientific Police Laboratory and the Forensic Medicine Laboratory were merged.

During the past few years, the Forensic Pathology Division prepared itself for the eventuality of a mass disaster. A response plan for this kind of situation was created and different responders followed adequate training. This preparation proved to be useful when a train derailed and exploded in downtown Lac-Mégantic, killing 47 people, and during the retirement home fire in L'Isle-Verte where 32 victims were found. During these two events, pathologists were rapidly deployed on site in order to assist policemen in the victim recovery process.

Today, the Forensic Pathology Division team consists of five pathologists, five pathologist assistants and three histology laboratory technicians. On average, 700 autopsies per year are performed in the Laboratory. Pathology is an area of forensic science that will most likely evolve greatly during the next few years, since several new technologies are now being introduced.

The introduction of molecular biology for the diagnosis of genetic cardiac diseases is very recent in the history of forensic pathology. DNA typing is performed for known diseases that do not present any visible sign at the autopsy. This analysis, dubbed "molecular autopsy", should take more importance for explaining sudden deaths. This diagnosis tool is already used by the Laboratory's pathologists in cases were the cause of death is unknown. The nascent collaboration between the Montreal Cardiology Institute and the Laboratory for the analysis of these cases is promising.

The place of radiology in the practice of forensic pathology should also evolve in the next few years. X-ray radiology has been integral to pathology since the early days of the Laboratory, but the precision of the instruments has increased over time. New technologies of medical radiology have appeared over time, but are still not used at the Laboratory. This should change over a 5 to 10 year horizon, as virtual autopsy (Virtopsy™) is introduced as a reliable technique to document wounds and orientate cases. In a virtual autopsy, a three-dimensional image is formed with magnetic resonance imagery (MRI) and helical X-ray computed tomography (CT). However, this should not replace real autopsies, since it has limitations, like all diagnostic acts.

Talks have been initiated in order to widen the Laboratory's mandate with respect to coroner autopsies. Since the end of the 1980s, some of the non-suspicious death autopsies is performed in hospitals. If these autopsies were brought back to the Laboratory, this would allow greater accountability and uniformity, for example because of the peer review system in place. A model similar to Ontario, where there are different responsibility levels between pathologists, is being considered. Moreover, a revision of the law on the research on causes and circumstances of death is being initiated at the Coroner's Office and could lead to a modification of the forensic pathologist's mandate.

The formation of forensic pathologists is now more uniform following the introduction of the forensic pathology subspecialty exam of the Royal College of Physicians and Surgeons of Canada and the subspecialty program. Before this date, new pathologists were certified anatomo-pathology specialists but had to follow a one-year internal training programme. The specialization of anatomo-pathologists in forensic pathology is now done in the subspecialty programme. The Laboratory wishes to develop the first francophone training centre in forensic pathology in North America, in collaboration with Quebec universities. The introduction of this training will also build bridges between the Laboratory and the academic community and research activities, which should increase the influence of the Laboratory and the quality of the pathologists' expertise.

4.2 | Odontology and Anthropology Division

Dr. Robert Dorion joined the Laboratory team in 1973, after having completed forensic odontology training at the Armed Forces Institute of Pathology in Washington, DC. In this area, the introduction of computers was a great change since databases were developed to store ante-mortem and post-mortem dental records for comparison ends. The arrival of coloured photography, then under ultraviolet (UV), infrared (IR) or alternating light allowed a finer analysis of sub-cutaneous haemorrhages in cases of biting. Dr. Dorion developed a system of wound sampling that uses a ring to fix the skin's shape. This technique is now used everywhere and is detailed in his book Bitemark Evidence. In 2004, he started an online odontology course, a collaboration between the Laboratory and McGill University. This course has a theoretical and a practical section, which makes it unique worldwide. In 2010, a team of forensic odontologists sharing cases was formed in order to disseminate knowledge in this area. Additionally, this has allowed the Laboratory to answer to the needs of mass casualties situations. This team includes a contract forensic anthropologist from Ontario, Renée Kosalka.

4.3 | Toxicology Division

At the time of the Laboratory's creation, toxicological analyses were carried out directly by pathologists such as Dr. Derome. However, the true father of forensic toxicology in Quebec was Franchère Pépin, hired in 1919. This pharmacist developed several analyses, including one of the first published methods for the quantification of ethanol in blood (1925). At the time, drugs of natural origin were prevalent (e.g. cocaine, morphine). As a reference point, barbiturates were commercialized in 1903 and amphetamines in 1933.

An important part of toxicological analysis rested on the observation of biological matrices, mainly gastric content (appearance and odour). A suspected poison isolated from gastric content was often tested on frogs to evaluate its effect and guide analyses.

Analytical techniques were mostly based on colorimetric reactions. The Laboratory's chemists had also developed a mercury vapour lamp based on the working principle of an emission spectrometer. The emission spectrum of the biological matrix extract was obtained on a photographic plate and compared with spectra of known metals for identification. As time went by, other tools became available, for example the hand-held spectroscope for detection of carboxyhaemoglobin (HbCO). Diluted blood was added in the spectroscope cell, which was then orientated towards a window on a sunny day. The appearance of two black strips confirmed the presence of HbCO.

Bernard Péclet was hired by the Laboratory in 1946. In addition to his work in forensic toxicology, he was a strong advocate for the specialization of forensic scientists and he became head of the Laboratory in 1972. When he was hired, the number of synthetic drugs was rapidly increasing. The Laboratory was one of the first to use a spectrophotometer to detect and identify drugs. This analysis was completed by the use of thin layer chromatography (TLC) for acidic, basic or neutral drugs. The presence of drugs on the TLC plates was revealed using different colorimetric reagents.

A number of instruments were bought in 1967 to accommodate the growing needs of the Laboratory. Before the move to Parthenais Street, a nuclear magnetic resonance instrument (NMR), spectrofluorometer, gas chromatograph (GC) and infrared (IR) spectrophotometer were acquired. Because of its size, the NMR had to be delivered to the fifth floor from the outside of the building, before floors 6 and up were built. Several specialists were hired in the different sections: this was the beginning of the specialization. Eventually, forensic toxicologists would specialize in analysis of either alcohol or drugs.

Since the foundation of the Laboratory, the matrix extraction process has greatly evolved. Initially, matrix extraction or preparation were specific for analytes or analyte families. For example, the Stas-Ogier method was used for alkaloids and the Nicloux method for carbon monoxide (CO). Liquid-liquid extraction (LLE) was then introduced. A typical extraction used 5 mL of matrix and 50 mL of solvent. The replacement of LLE by solid phase extraction (SPE) in the early 1990s allowed reduction of the matrix volume to 1 mL and solvent volume to 8 mL. SPE extraction was automated for a short period of time. However, use of robots was quickly dropped due to contamination issues. Contamination became obvious with the introduction of more sensitive instruments such as LCMS. The type of biological matrix analyzed also evolved. Matrices considered as alternative nowadays (brain, liver, lungs, etc.) were analyzed much more at the time.

In 2009, the Scientific Working Group in Toxicology (SWGTOX) was created in the US. The aim of this group is to develop and disseminate working standards in forensic toxicology. However, the collaboration and evaluation movement started long before that. In the 1990s, Canadian laboratories (RCMP, Ontario and Quebec) had developed a system of case exchange that acted as proficiency testing. Eventually, these cases were replaced by matrices doped by the laboratories. The goal was to challenge the other laboratories so that everyone could evaluate the limitations of their analytical process. Quality control practices have continually been evolving since that time. Written protocols, uncertainty calculations, peer revision and method validation protocols have now been introduced. A prime example is the peer revision system introduced in 2004. This has brought substantial modifications to the work of forensic toxicologists and laboratory technicians and has improved results and practice quality.

The introduction of mass spectrometry (MS) coupled to chromatography was a revolution in toxicological analysis. In 1978, the Laboratory acquired its first mass spectrometer for $350,000, a Finnigan 4000. This MS was coupled to a GC which used a megabore column with a helium flow of 30 to 40 mL/min. As a reference point, a 1 mL/min flow is typically used in modern

GC-MS. A TSQ70 was then bought in 1986, followed by an ion trap in 1990. This instrument showed numerous issues of trap saturation during analysis of high concentration extracts, coupled with a high cycle time. It was eventually replaced by a GC-MS (quadrupole)/NPD (gas chromatography – mass spectrometry/nitrogen phosphorus detector) in 2000. The Laboratory was one of the first in North America to acquire LC-MS (liquid chromatography – mass spectrometry) technology. Indeed, an LCQ was bought in 1996 followed by a TSQ7000 in 2000. This instrument used one to two nitrogen gas cylinders per day for the nebulization gas! The arrival of the LC-MS allowed analysis of thermolabile molecules impossible to treat by GC-MS. For example, two multiple homicide cases from Canada using digitoxin were solved around 2000 using this technology. Digitoxin is a drug prescribed mostly in Europe to treat cardiac insufficiency.

One of the recommendations of the 2009 National Academy of Sciences report (*Strengthening Forensic Sciences in the United States: A Path Forward*) and the 2012 *House Report* was to create or reinforce bonds between forensic science laboratories and universities. This has been the path taken by the Toxicology Section for a few years now. Interns currently in their bachelor studies and graduate students have been an integral part of the research and development projects. This trend should grow stronger in the next years. Bonds with partner organisms such as Quebec National Institute of Public Health (INSPQ), Health Canada, Coroner's Office, Provincial Police (SQ), municipal police forces and Quebec National Police School (ENPQ) are also expected to grow. Training sessions, exchange of analytical knowledge and results sharing is already more frequent than before.

A recurring goal of the Division is the improvement of toxicological analyses and report production time delays. A great improvement has been noted since 2010. This progression is partly attributable to the toxicologists and technicians recently hired. However, the key factor was research and development projects leading to methods of simultaneous quantification of analytes. These methods greatly decreased the turnaround time. This was essential to face the increase in the number of files brought by the implementation of the Drug Recognition Expert (DRE) program. Initiated in 2008, this program allows the arrest of individuals suspected of driving under the influence of drugs other than alcohol. Following a 12-step physical evaluation, a biological sample is collected and analyzed at the Laboratory to confirm the drug recognition expert's evaluation. About 300 DRE cases per year are analyzed currently, but this number is expected to grow as the program gains momentum. The delay reduction aim is still present in the Toxicology Division. Indeed, there are more and more discussions internationally about 24-hour toxicological analysis. An analysis this fast would more directly guide the coroner in his investigation and the pathologist in his autopsy. For example, a preliminary result of a toxic drug concentration in the victim's system could be given to the pathologist before the autopsy even started. In order to reach this goal of a 24-hour analysis, the development of new extraction and analysis methods is essential. Validation of blood extraction by protein precipitation and an LC-MS/MS method for simultaneous screening of 300 analytes are ongoing projects that could help achieve this goal. The acquisition of an LC-Q-TOF (a mass spectrometer with a quadrupole and a time of flight analyzer) would allow a more general drug screening. However, one must not forget that even the most advanced instruments will not replace the judgement of a forensic toxicologist.

5 | ADMINISTRATION AND QUALITY ASSURANCE SECTION

Work performed in a forensic science laboratory is obviously first and foremost of a scientific nature. But, to be performed properly, this work requires constant administrative support. The Administration and Quality Assurance Section is supportive of the scientific sections' activities. Its mission is to ensure that the scientific sections have at their disposal the financial, human, material and informational resources necessary for their respective missions and to reach their objectives. Five divisions compose this section: Quality Assurance, Imaging, Exhibit Management, Document Management and Information Technologies.

5.1 | Quality Assurance Division

By the very nature of the work performed in the Laboratory, it is essential that the results be error-free. All the personnel are aware of this requirement and the quality assurance program was set up in order to refine practices, as well as standardize and apply them throughout the Laboratory. Amongst the important elements of this strategy, there is sensitization of the employees to the importance of the program, increased documentation of the various activities, peer review of all cases, as well as validation of the analytical methods and training on court testimony. Thanks to everyone's efforts, the Laboratory thus obtained in 2009 its ISO 17025 certification (standards for analytical laboratories) as well as CAN-P-1578 specifications (Canadian standard for forensic sciences laboratories).

One of the future challenges for the Quality Assurance Division will be to pursue the development of the quality assurance programme, not only to maintain what has already been established, but also to ensure the programme's application to those new technologies and techniques that will be utilized in the Laboratory in the future.

5.2 | Imaging Division

Photography has always been a part of the Laboratory. From the beginning, Dr. Derome used it to illustrate his conclusions in ballistics cases; to do so, he had developed techniques for macrophotography (where the camera is very close to the subject), in spite of the technical difficulties of the time. Following photography's evolution, the Laboratory went from using silver-coated glass plates to Polaroids. Nowadays, using a digital camera is the norm. However, in 2000, when the first digital camera was introduced, it had to do three sweeps of the subject, one per primary colour, and it took 2–3 minutes to assemble a colour picture. Today, with computers and image processing software, it is possible to go beyond the precision of the best analogue cameras.

The Laboratory has also seen an evolution in surveillance cameras, going from fixed images to video. In the 1970s, there was a great demand to extract images from these types of cameras because the police departments were not at all equipped to do this kind of work. In the 2000s, the Laboratory acquired a highperformance digital platform, the technicians were trained and became involved in the SWIGIT (Scientific Working Group on Information Technology), in order to be able to further the treatment of images. Today, most of the police departments have purchased sophisticated equipment of their own and the requests to the Laboratory are therefore limited to the most difficult cases.

Well-known for the quality of its image presentations, the goal of the Imaging Division is to make those images as clear as possible ("a picture is worth a thousand words"). The task of arriving at conclusions based on these images belongs to the investigator.

Challenges to the profession are of two types: quality and usefulness of the images to the specialists, and quality of evidence presentation in court. To help to rise to these challenges, many new technologies are emerging. In the first case, 3D technology represents an enormous potential, although it is still lacking in precision. It already enables a virtual model of crime scene to be recreated, or the comparison two objects in 3D, such as a skull with a wound and a blunt object. In the second case, use of animation software could render presentations easier to understand when the experts are in court.

5.3 | Exhibit Management Division

Before the 1990s, an employee was stationed at the laboratory reception and his work was to log the exhibits' arrival date and time as well as any other relevant information in a large book. The exhibits were then transferred directly from the claimer to the department from which analysis were needed, thus creating important coming and going of people all around the premises. It was only at the beginning of the 1990s that a reception section was implemented on the fifth floor to better manage the exhibit's chain of custody. In 1995, a computerized laboratory information management system (LIMS) was implemented. Nowadays, terminals, bar-code readers and printers are installed in every department and eliminate the need to manually transcript every movement of the exhibits. In its first year of operation, 5,110 cases and 16,782 items were input into the LIMS; in 2013, these numbers were respectively 8,872 and 27,499.

In 2007, because of an increasing demand, an extranet portal was opened to facilitate the management of the different requests sent to the laboratory i.e. the GDE system (*Gestion des demandes d'expertise*). This system enabled the claimer to submit their analysis request through a secure web portal, reducing again the need for manual transcript and related errors. The different clients can also be kept informed of their cases' progress through this website.

Almost 20 years later, and after many updates, more than 180,000 cases have been input into the LIMS. It is therefore essential to ensure that this tool is always accessible to all the personnel as well as all the clients through adequate training and constant update.

Currently, the reception area contains close to 11,000 exhibits. The next challenge of the exhibit management division will be to review the process through which the evidences are stored, sent back to their owner or destroyed in order to minimize the actual lack of storage space.

5.4 | Document Management Division

The Laboratory is fortunate to have a large area reserved for its scientific library. The forensic specialists must keep abreast of developments in their various domains of expertise. As such, some use the library as individual workspace. The Documentation Center's personnel also inform specialists of new publications, and ensure that the different resources are available electronically, thereby facilitating their access.

The Documentation Center personnel are also responsible for archiving the judicial expertise files generated by Laboratory specialists' past and present work. They must ensure that the files are complete/secure and that they can be rapidly available when necessary (for example, for a presentation to the courts). This involves very efficient file archival management system – traceability being essential in the judicial area. The volume and number of files is always increasing, so computerization of the case files is ongoing as it will facilitate management of all the information. Currently, implementation of an electronic case file systems is partially completed in the Biology department, the Laboratory's most important department in terms of volume of files. Implementation will continue in this department, and then in the rest of the Laboratory in the near future.

5.5 | Information Technologies Division

Information technology (IT) has become an important part of the Laboratory in the last fifteen years partly because of the drastic evolution of scientific tools. Whether it is providing an employee with a workstation, developing various databases to facilitate work while maintaining data security, or keeping up with the scientific and technological development of the various disciplines, information technology is now an integral part of all the work performed in the Laboratory.

Today, the IT team is responsible for the management of more than 250 microcomputers, telecommunication devices, mobile and videoconferencing equipment, as well as counselling Laboratory personnel during the acquisition of different scientific technologies.

The daily challenge for the IT team is to keep up to date in order to respond to the Laboratory's various technological needs, while also ensuring the security of information. In the coming years, numerous challenges await IT, notably the replacement of the LIMS.

6 | CONCLUSION

Today, the Laboratory performs forensic science analyses for the province of Quebec's 8.1 million population. In 2013, the Laboratory handled about 8,800 cases and employed more than 150 scientists and support staff. The Laboratory's main clients are the provincial and municipal police corps, the prosecutors of the Quebec Director of Criminal and Penal Prosecutions, the different courts, the coroners, the Quebec Wildlife and Parks Agency, the Quebec Police College and the Canadian Police College.

In 2001, the Government of Quebec officially named the 1701 Parthenais Street building the Wilfrid Derome Building in honour of the forensic sciences pioneer.

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