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A journey into the innovations and expertise of Dubai police and the general department of forensic science and criminology

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Abstract

This manuscript offers an in-depth exploration of the Dubai Police and its General Department of Forensic Science and Criminology, emphasizing their critical role in law enforcement through advanced forensic science and innovative practices. Beginning with a historical overview, it traces the evolution of forensic disciplines from Edmond Locard's foundational principles to Sir Alec Jeffreys' groundbreaking DNA profiling techniques. The manuscript details the structure and functions of specialized sections within the department, including Biology and DNA, Forensic Chemistry, Forensic Toxicology, Firearms and Tool Marks, Questioned Documents, Forensic Explosive, Forensic Fire Investigation, Forensic and Mechanical Engineering, and Nuclear Physics.

Key achievements, such as the Biology and DNA Section's processing of thousands of cases and the generation of highly discriminating DNA profiles, are highlighted. The manuscript also addresses the department's challenges, including the rapid evolution of technology and the increasing complexity of crimes. Future plans to enhance capabilities through investment in new technologies, international collaboration, and continuous professional development are outlined.

By showcasing the department's commitment to innovation, excellence, and public safety, this manuscript underscores the pivotal contributions of the Dubai Police and its forensic department to crime resolution and community safety. The insights provided aim to foster a deeper understanding of the critical role of forensic science in the criminal justice system.

Keywords: Dubai Police; General Department of Forensic Science and Criminology; Forensic Science; DNA Profiling; Forensic Chemistry; Forensic Toxicology; Firearms and Tool Marks; Questioned Documents; Forensic Explosive Investigation; Forensic Fire Investigation; Forensic Engineering; Nuclear Physics in Forensics; Crime Scene Investigation; Law Enforcement Innovation; Public Safety; Forensic Technology

1. Introduction

The concept that offenders both leave and carry trace evidence during criminal acts was first introduced by Locard nearly a century ago [1] and further discussed by Inman and Rudin [2]. This understanding has led to the development of various forensic disciplines dedicated to detecting such traces. A significant milestone was the groundbreaking discovery by Sir Alec Jeffreys and his colleagues [3,4], who found the ability to generate distinct genetic profiles from biological materials and successfully applied them to identify individuals involved in criminal activities. Technological advancements subsequently enabled the rapid and cost-effective generation of highly discriminating DNA profiles from diverse biological sources [5–7]. Furthermore, the establishment of standardized practices across jurisdictions, the implementation of offender DNA databases, and the enactment of associated legislation [8–11] have progressively elevated the role of DNA in identifying both perpetrators of crimes and innocent individuals who have been wrongfully

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accused [12–19]. These methodologies have also played a crucial role in identifying victims of disasters and missing persons [20–23].

An important breakthrough emerged when it was discovered that DNA could be detected from non-visible biological material left on surfaces through direct contact with the skin [24-25]. This observation expanded the range of items suitable for DNA profiling and broadened the application of DNA analysis to various scenarios [5,12,16,26-29]. Initially met with skepticism within the forensic community, the ability to generate profiles from touched objects was later verified and embraced as a valuable tool by law enforcement agencies. In several jurisdictions, samples collected from touched objects now constitute more than half of the total samples processed for DNA profiling [14,30-31]. Touch or trace DNA plays a crucial role as evidence due to its ability to be recovered from a wide range of touched items or surfaces, establishing connections between suspects and crimes. Common sources of trace DNA include tools, weapons, clothing, and various touched or used items. However, collecting this type of DNA presents challenges compared to other biological evidence, as the quantity of DNA collected can be influenced by multiple factors [32-50].

The field of forensic chemistryhas a long history, tracing back to the early 19th century when chemists began analyzing poisons in criminal investigations. Notable cases such as the Marsh test for arsenic detection in 1836 laid the foundation for modern forensic chemistry techniques [51]. This field has since evolved to include a wide range of chemical analyses, crucial for detecting substances like drugs, explosives, and poisons in various criminal cases [52-53]. Similarly, forensic toxicologyemerged as a distinct discipline in the late 19th and early 20th centuries. Pioneers like Mathieu Orfila, often referred to as the father of toxicology, published works on the effects of poisons on the human body [54]. This field focuses on detecting and interpreting the presence of drugs, alcohol, and other toxic substances in biological samples, playing a vital role in overdose cases, poisoning, and substance abuse investigations [55-57].

The analysis of firearms and tool marks dates back to the early 20th century, with significant advancements made by experts like Calvin Goddard. Goddard developed techniques for comparing bullets and cartridge cases under a microscope [58]. This discipline involves examining firearms, ammunition, and tool marks to link them to criminal activities, providing crucial evidence in cases involving shootings and break-ins [59]. Questioned document examination has its roots in the late 19th century. Early forensic document examiners like Albert S. Osborn, who authored "Questioned Documents" in 1910, established principles for analyzing handwriting, signatures, and printed materials [60]. This field is essential in fraud investigations and the verification of legal documents [61].

Forensic explosive investigation began to take shape in the mid-20th century, with significant contributions during and after World War II as experts developed methods to investigate explosive devices and blast scenes [62]. This field is critical in counter-terrorism and criminal investigations involving explosives [63]. Similarly, forensic fire investigation developed alongside fire safety engineering, with early techniques focusing on determining the origin and cause of fires. This field became more formalized in the 20th century, aiding in arson investigations and fire-related insurance claims [64].

Forensic and mechanical engineering applies principles from engineering to analyze structural failures, vehicle accidents, and mechanical malfunctions. This interdisciplinary field has grown with advancements in engineering and materials science, helping to understand the causes of accidents and incidents involving machinery and structures [65]. The application of nuclear physics in forensics is relatively recent, gaining prominence in the late 20th century. This field involves analyzing radioactive materials, providing insights into cases involving nuclear substances and ensuring public safety [66-68].

2. The City of Dubai, Its Police Departments, and Its Forensic Specialized Units

2.1. Overview of Dubai

Dubai, one of the seven cities known as Emirates, is a constituent of the United Arab Emirates (UAE). While Abu Dhabi serves as the capital city, Dubai stands as the most populous city, with approximately 3.4 million inhabitants [69]. Initially believed to have originated as a fishing village in the early 18th century [70], Dubai has transformed into an international hub that attracts people from 195 different nationalities who live and work within the city [71]. Following the discovery of oil in 1966, Dubai experienced remarkable economic growth and rapid urbanization, resulting in its evolution from a desert village into a thriving metropolis that encompasses numerous residential, commercial, sports, medical, and tourism projects [72-73].

2.2. Dubai Police Force

The establishment of the Dubai Police Force in 1956 aimed to safeguard the city's residents and uphold justice. It is recognized as one of the most progressive police forces in the Arab region, known for introducing advanced law enforcement techniques such as electronic fingerprinting and forensic DNA testing [74]. In addition to the eleven police stations that cover the city, the Dubai Police Force operates various departments, including the General Department of Operations, General Department of Artificial Intelligence, General Department of Criminal Investigation, and General Department of Forensic Science and Criminology. These departments collaborate to combat crime and ensure public safety [75].

3. General Department of Forensic Science and Criminology

3.1. Establishment and Growth

The General Department of Forensic Science and Criminology, initially established in 1981 as the first Forensic Lab under the General Department of Criminal Investigation, has grown into one of the largest forensic labs in the Middle East. The department is staffed with highly skilled forensic scientists, experts, technicians, and medical examiners, handling over forty thousand forensic cases annually [39]. Notably, the Forensic Department holds international accreditations such as ISO 17025. In May 2022, it launched a regional forensic science platform focused on collaborative research and training [76-77].

3.2. Ky Divisions and Functions

Within the General Department of Forensic Science and Criminology, the Department of Specialized Evidence is a pivotal division encompassing several sections, each contributing uniquely to solving crimes:

- *Biology and DNA Section:* This section is divided into three units: the Biology division, the DNA division, and the Reference Samples division. The purpose of the forensic Biology and DNA field is to provide critical evidence in criminal investigations by analyzing biological materials to identify individuals involved in criminal activities. The Biology division conducts examinations of exhibits, performs presumptive and confirmatory tests, and collects samples. The DNA division oversees the entire DNA profiling process, from DNA extraction to data analysis and comparison with the DNA database. The Reference Samples division handles samples from suspects or individuals under investigation, conducting direct amplification, data analysis, and comparison with the DNA database. These efforts are crucial for identifying perpetrators, exonerating the innocent, and linking suspects to crime scenes.
- *Forensic Chemistry Section:* This section performs chemical analyses to detect and identify substances such as drugs, explosives, and poisons. The expertise in chemical analysis helps in solving drug-related crimes, arson investigations, and cases involving toxic substances. Forensic chemists use a variety of techniques, including chromatography, spectroscopy, and mass spectrometry, to analyze evidence from crime scenes. They play a critical role in detecting illicit drugs, determining the chemical composition of explosives, and identifying poisons in toxicological investigations.
- *Forensic Toxicology Section:* Specialized in detecting and interpreting the presence of drugs, alcohol, and other toxic substances in biological samples, this section plays a vital role in determining the cause of death in overdose cases, poisoning, and substance abuse investigations. Forensic toxicologists analyze bodily fluids and tissues for the presence of toxic substances, providing crucial evidence in cases of suspected poisoning, drug overdoses, and impaired driving. Their analyses help to establish the cause and manner of death, contributing to both criminal investigations and public health assessments.
- *Firearms and Tool Marks Section:* This section examines firearms, ammunition, and tool marks to link them to criminal activities. By analyzing bullet trajectories, gunshot residues, and tool impressions, forensic experts can provide crucial evidence in cases involving shootings and break-ins. Firearms examiners compare bullets and cartridge cases to specific weapons, while tool mark examiners analyze marks left by tools at crime scenes. Their work is essential in linking suspects to firearms and tools used in the commission of crimes.
- *Questioned Documents Section:* Experts in this section analyze handwriting, signatures, printed documents, and other questioned materials to detect forgeries, alterations, and counterfeits. This analysis is essential in fraud investigations and legal document verifications. Document examiners use various techniques, such as handwriting comparison, ink analysis, and digital imaging, to authenticate documents and identify alterations. Their expertise is crucial in cases of identity theft, contract disputes, and financial fraud.
- *Forensic Explosive Section:* This section investigates explosive devices, blast scenes, and related evidence to determine the type of explosives used and reconstruct the events leading to explosions. This expertise is critical in counter-terrorism and criminal investigations involving explosives. Forensic explosive experts analyze bomb

components, residues, and blast patterns to identify the materials and methods used in explosive devices. Their findings help to prevent future attacks and bring perpetrators to justice.

- *Forensic Fire Investigation Section:* Specializing in the investigation of fire scenes, this section determines the origin and cause of fires, whether accidental or intentional (arson). Their findings are crucial in arson investigations and fire-related insurance claims. Fire investigators examine burn patterns, fire debris, and witness statements to determine how and where a fire started. Their work helps to identify arsonists, prevent future fires, and resolve insurance disputes.
- *Forensic and Mechanical Engineering Section:* This section applies engineering principles to analyze structural failures, vehicle accidents, and mechanical malfunctions. Their analyses help in understanding the causes of accidents and incidents involving machinery and structures. Forensic engineers investigate building collapses, traffic accidents, and machinery failures to determine the factors that contributed to these events. Their expertise is vital in improving safety standards and preventing future incidents.
- *Nuclear Physics Section:* Utilizing advanced techniques in nuclear physics, this section analyzes radioactive materials and provides insights into cases involving nuclear substances. This expertise is vital in addressing threats related to nuclear materials and ensuring public safety. Nuclear forensic scientists analyze samples for radioactive isotopes, helping to trace the source and history of nuclear materials. Their work is crucial in preventing nuclear terrorism, investigating illegal trafficking of radioactive materials, and supporting national security.

4. Key Achievements and Contributions

The department has been instrumental in solving numerous high-profile cases, ranging from homicides to complex financial crimes. Their expertise in forensic science has often provided crucial evidence leading to the resolution of cases. Dubai's General Department of Forensic Science and Criminology is known for its continuous innovation. They have introduced several state-of-the-art technologies in their operations, including advanced DNA testing methods and digital forensics tools. The department collaborates with various international forensic science organizations and participates in global conferences and training programs to stay at the forefront of forensic science advancements.

As an example from the Biology and DNA Section, between 2019 and 2021, a total of 6,277 cases were received, each case comprising one or multiple exhibits. During this period, a collection of 14,552 samples was obtained from these examined items. However, it is important to note that only 8,696 samples underwent processing for DNA profiling. It is common practice not to process all collected samples for DNA profiling due to cost considerations; some are retained as backup samples. Prioritization typically occurs based on the relevance of the samples to the case scenario. Moreover, samples that were not initially processed may undergo analysis later if required by the court or legal systems. The DNA profiling process yielded 7,103 positive DNA results, achieving an overall success rate of 82% for all types of samples. Within the Biology and DNA Section, positive DNA results for forensic case trace profiles are characterized by DNA profiles exhibiting homozygous or heterozygous alleles (forming a single DNA profile) with possible dropout, or a combination of alleles (forming a mixed DNA profile), in a minimum of eight loci. Any instance where there are alleles present at eight loci or more is considered a positive DNA result. These loci are identified through the amplification of a sample using the GlobalFiler™ PCR Amplification Kit. It is required that these loci encompass eight of the original CODIS Core Loci, along with the Amelogenin locus. This rigorous criterion ensures that the DNA profiles generated within the Biology and DNA Section meet the standards for positive identification, thereby maintaining the integrity and reliability of forensic analyses.

5. Challenges and Future Directions

5.1. Current Challenges

Despite its advancements, the General Department of Forensic Science and Criminology faces several significant challenges. One of the primary challenges is the rapid evolution of technology. As new technologies emerge, the department must continually update its equipment and methodologies to stay current. This necessitates ongoing training and professional development for forensic scientists and technicians to ensure they are proficient in using the latest tools and techniques. Additionally, the integration of new technologies into existing systems can be complex and costly, requiring substantial investment in both time and resources.

Another challenge is the increasing complexity of crimes. With the advent of sophisticated cybercrimes, digital forensics has become an essential component of modern investigations. The department must stay ahead of cybercriminals who use advanced techniques to commit fraud, identity theft, and other online crimes. This requires continuous development

in digital forensics capabilities, including the analysis of encrypted data, social media, and emerging technologies such as blockchain.

The sheer volume of cases and evidence also presents a logistical challenge. The department processes thousands of cases annually, each requiring meticulous examination and analysis. Managing this workload while maintaining high standards of accuracy and efficiency is a constant balancing act. The need for quick turnaround times in forensic analyses can put pressure on the department, potentially affecting the thoroughness and quality of investigations.

Additionally, the department faces challenges related to inter-agency and international collaboration. Crime often transcends borders, requiring cooperation with other law enforcement agencies and forensic laboratories. Differences in legal frameworks, standards, and procedures can complicate these collaborations, necessitating efforts to harmonize practices and improve communication and data sharing across jurisdictions.

5.2. Future Plans and Developments

To address these challenges and continue improving its capabilities, the General Department of Forensic Science and Criminology has outlined several strategic plans and developments. One of the primary goals is to invest in cutting-edge technologies that enhance forensic analysis. This includes the acquisition of advanced DNA sequencing equipment, digital forensics tools, and automated systems for evidence processing. By integrating artificial intelligence and machine learning, the department aims to increase the efficiency and accuracy of forensic analyses, enabling faster case resolutions.

The department also plans to enhance its collaboration with international forensic bodies. By participating in global conferences, training programs, and joint research initiatives, the department can stay abreast of the latest developments in forensic science and adopt best practices from around the world. These collaborations also facilitate the standardization of forensic procedures, improving the reliability and comparability of results across different jurisdictions.

Furthermore, the department is committed to continuous professional development for its staff. This involves providing regular training sessions, workshops, and certification programs to ensure that forensic scientists and technicians are skilled in the latest methodologies and technologies. The department also encourages staff to pursue advanced degrees and research opportunities, fostering a culture of innovation and excellence in forensic science.

In terms of infrastructure, the department plans to expand its facilities to accommodate the growing demand for forensic services. This includes the construction of new laboratories and the enhancement of existing ones with state-of-the-art equipment. Additionally, the department is exploring the use of remote and mobile forensic units that can be deployed to crime scenes, improving the speed and accuracy of evidence collection and analysis.

To address the increasing complexity of crimes, the department is enhancing its specialized units in emerging areas of forensic science. This includes bolstering dedicated teams for cyber forensics, environmental forensics, and forensic psychology. By building and expanding expertise in these specialized fields, the department aims to better handle complex cases and provide comprehensive forensic support to law enforcement agencies. These specialized units are equipped with advanced technologies and methodologies to tackle the unique challenges posed by modern criminal activities, ensuring that the department remains at the forefront of forensic innovation and effectiveness.

Lastly, the department aims to improve its outreach and education efforts. By engaging with the public, law enforcement agencies, and the legal community, the department seeks to raise awareness about the importance of forensic science in the justice system. Educational programs, public lectures, and collaborations with academic institutions will help to build a greater understanding of forensic science and its critical role in solving crimes and ensuring justice.

6. Conclusion

The Dubai Police and its General Department of Forensic Science and Criminology play a pivotal role in maintaining law and order in Dubai. Through their dedication to forensic science and innovation, they have significantly contributed to the effective resolution of crimes and the overall safety of the community. The department's ability to adapt to new technologies and methodologies ensures that they remain at the forefront of forensic science.

The success of the department can be attributed to its comprehensive approach, which includes robust training programs, international collaborations, and continuous investments in state-of-the-art technologies. By fostering a

culture of excellence and innovation, the department not only enhances its forensic capabilities but also sets a benchmark for forensic science practices globally.

Each specialized unit within the department, from Biology and DNA to Forensic Toxicology and Cyber Forensics, plays a crucial role in solving complex cases and providing critical support to law enforcement agencies. Their meticulous work in evidence collection, analysis, and interpretation has been instrumental in solving high-profile cases, exonerating the innocent, and ensuring that justice is served.

Moreover, the department's proactive stance on addressing emerging crime trends, such as cybercrime and environmental crime, demonstrates its commitment to evolving with the changing landscape of criminal activity. This adaptability is key to maintaining public trust and confidence in the criminal justice system.

In conclusion, the Dubai Police and its General Department of Forensic Science and Criminology stand as a testament to the power of science and technology in law enforcement. Their ongoing efforts not only enhance the safety and security of Dubai but also contribute to the global body of forensic science knowledge, making them a model for other forensic institutions worldwide.

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