Brief Introduction to Forensic Science and Forensic in Australia and China

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Chapter One

Introduction of Forensic Science

1.1 Introduction

Finding the justice for judicial system by using scientific method analysis to deal with crime issue is the reason why forensic science exist. By collecting and analysis evidence from crime scene, forensic science is able to detect the truth behind of crime scene, which it helps judge and jury in the court of the law to evaluate someone's innocent or guilty.

There is a fact that forensic science firmly relies on law system no matter which countries they are or what kind of law systems they have around the world. In other words, forensic science in different counties which have different law systems might have different forensic history, subjects or strategy. However, even the law systems can be different, the gap between different systems of forensic science are bridging less and less. Following the speeding trend of economic globalization, forensic science also cannot avoid being influenced by this tide, especially for forensic standard sharing and research cooperation (Lucas, D. 2011). The International Association of Forensic Sciences (IAFS) was established by 6 countries (the United Kingdom, the United States, Switzerland, Belgium, Denmark and Canada) to share forensic information of English language every three years globally (Lucas, D. 2011). Until 2011, there were ready 109 countries attending the IAFS meeting to exchange forensic knowledge and research (Lucas, D. 2011).

Personally, I consider that the difference of forensic science between different countries are result from the difference of judicial systems, and the technique and strategy of forensic science are not significantly different between each country. Firstly, evidence of forensic science comes from searching crime scene (Miranda, D. 2015) and crime scene investigation is the first approach of forensic science in the crime scene for trekking and collecting evidence, as this first step can influence the quality of forensic analysis (Mozayani, A., & Parish-Fisher, C. 2017). Secondly, forensic science composited of multiple science such as biochemistry, medicine, anthropology, pathology and et al and the development of forensic science in the future will focus on governorship of forensic science, technology of forensic science and legal-science interface (Daeid, N. N. 2010). In conclusion, the global forensic science faces the challenge from improving the quality of crime scene investigation and reaching new level of scientific technology. For the legal system

related forensic science, the administration and strategy of forensic science might be various between different countries as forensic science must adapt to the specific circumstance of society.

Briefly, the technology for crime scene investigation and analysis evidence of forensic science should not have big difference, but the strategy and management of forensic science can be different for different countries which have different society background. This dissertation will discuss what modern forensic science it is, the evidence of forensic science and forensic science in Australia and China. For the first part, we will discuss forensic science from crime investigation, evidence analysis and forensic court testimony. The second Chapter will focus on the definition and characteristics of forensic evidence including the first and second generation. The third chapter of this article will discuss the forensic science in Australia and China.

Personally, I consider that the difference of forensic science between different countries are result from the difference of judicial systems, and the technique and strategy of forensic science are not significantly different between each country. Firstly, evidence of forensic science comes from searching crime scene (Miranda, D. 2015) and crime scene investigation is the first approach of forensic science in the crime scene for trekking and collecting evidence, as this first step can influence the quality of forensic analysis (Mozayani, A., & Parish-Fisher, C. 2017). Secondly, forensic science composited of multiple science such as biochemistry, medicine, anthropology, pathology and et al and the development of forensic science in the future will focus on governorship of forensic science, technology of forensic science and legal-science interface (Daeid, N. N. 2010). In conclusion, the global forensic science faces the challenge from improving the quality of crime scene investigation and reaching new level of scientific technology. For the legal system related forensic science, the administration and strategy of forensic science might be various between different countries as forensic science must adapt to the specific circumstance of society.

1.2 About Forensic Science

The definition of forensic science can be described as “provision of information to help answer questions of importance to investigators and to courts of law” (Jackson et al, 2006). Forensic science is a complex science composed of criminal science, biological science, chemistry science, medical science and et al (Siegel, J. 2016). The original word, forensic, comes from Latin as meaning of “public” or “open court” and that makes forensic regarded as using science to deal with issues of public (Siegel, J. 2016).

Today, the modern conception of forensic science is: using scientific method and technology to find and analysis related evidence, which it helps the court of law deal with criminal or civil offense (Jackson, G. et al. 2006; Siegel, J. 2016). As result, evidence is the key of forensic science. Any evidences from criminal

scene and criminal investigation to prove guilty or innocent behaviour of individuals by scientific method can be regarded as the responsibility of professional forensic science (Leung, 2006). Furthermore, forensic science also helps to deal with issues of civil litigation and argumentation. Also, forensic science can involve massive disaster and anti-terrorist for personal identification to help both domestic and national security (Leung, 2006). Additionally, there are two different views about the basic role and discipline of modern forensic science. One stands with that forensic science is rigorous science so that pure scientific analysis without influence of side information is essential to avoid bias which might influence the results of analysis potentially. The other view agrees with that the forensics science contribute scientific evidence to deal with criminal issue and understanding related criminal context and information can help make forensic analysis work effectively.

Forensic science shares similar definition and ranges around the world as the requirement of justice system and the basic human right. Enviably, forensic can be regarded as the viaduct linking the judiciary, law enforcement at legislation area, because it provides scientific method to connect the relationship between the criminal scene investigation and law issues. This is an essential part to build the justice of the law by a long-term view (Leung, 2006).

Surrounding with forensic interested evidence, the general missions of forensic are divided into three parts: criminal scene investigation for finding evidence, evidence analysis and court testimony of evidence.

1.2.1 The crime scene investigation

Crime investigation is a part of forensic science using scientific tools to process, search and deal with the questioned issues of fact at the place of crime object (Millen, P. 2000). The forensic investigation at crime scene aims to establish original scene when the crime happened, identify related evidence (including witness), distinguish innocent and responsible individuals and et al. The investigator who has knowledge of forensic science and investigative mind has responsibility to exam the crime scene by following scientific process to collect information (Millen, P. 2000). The investigator of crime scene have to review and reconstruct the finding (evidence) from crime scene as the quality of crime investigation is related to the quality of forensic evidence analysis (Millen, P. 2000). Jackson and Jones (2006) emphasised that forensic investigation begins with the observation of forensic expert to help address the unknown question and hypothesis as finding lead, and experts opinion of forensic investigation comes from the fact or uncertain event (Jackson, G. Jones, S et al 2006).

The crime scene investigation is associated with finding evidence for forensic science (Siegel, J. 2016). However, crime scene investigation is different from criminal investigation. For crime scene investigation, it focus on searching, recording and collecting evidences related the criminal behaviour around criminal scene, such as fingerprints, blood, sperm stain and et al (Siegel, J. 2016). Evidence from crime scene need to be protected to avoid post damage then be stored and sent to forensic expert for forensic analysis. The range of criminal investigation is wider than criminal scene investigation. It works around all criminal intelligence instead of only evidence (Siegel, J. 2016). For example, targeting suspect, linking evidence, witness survey and et al.

1.2.2 Evidence analysis

Evidence analysis is the major part of forensic science and this usually rely on forensic laboratory (Siegel, J. 2016). Generally, the work of forensic laboratory includes forensic pathology, forensic biology, forensic anthropology, toxicology, forensic odontology, forensic entomology, psychiatry, multimedia and digital evidence, criminalistics, forensic engineering science and questioned document (Siegel, J. 2016). These sections also are considered as international forensic laboratory as well, as they are generally (Siegel, J. 2016). However, different countries may have various forensic laboratory systems to adapt different criminal environment.

Depending on the different type of criminal cases and different requirements of evidence analysis, forensic scientist have plays different roles with related forensic laboratory system. Even through different forensic scientists apply different knowledge for evidence analysis, the core still surround with basic three forensic responsibilities which mentioned before, criminal scene investigation, evidence analysis and court testimony of evidence. Some examples of forensic scientists and laboratory analysis involves the following objects:

- Forensic Entomology

Analysis of insects, larvae and maggots around the human remain at the criminal scene, aims for estimate time of death and provide related environment information of criminal scene (Siegel, J. 2016).

- Forensic Toxicology

Works for suspected illicit drugs, poisons and other chemical substance which associated with related evidence from criminal scene (Siegel, J. 2016).

- Forensic Pathology

Forensic autopsy of external examination and internal examination for post-mortem interval, aims for find the cause and manner of the death. Classification of violent deaths, and involves wound and trauma analysis (weapon type, injury pattern and et al) (Siegel, J. 2016).

- Forensic biology

Works for hair analysis and DNA analysis from blood, semen, saliva and human tissue. Aims for personal identification and paternity test (Siegel, J. 2016).

- Forensic Anthropology

Human skeleton and human bone fragment analysis for sex estimation, age estimation and ancestry estimation, sometimes include skeleton trauma analysis (Christensen, A., Passalacqua, N., & Bartelink, E. 2013).

- Forensic Odontology

Focus on dentition analysis include bite marks. Works for identification of victim and matching bite marks to defendant (Siegel, J. 2016).

- Forensic Firearms, tool marks and explosion

Analysis ballistics include bullet mark and powder residues et al. For explosive case, works for bomb and arson identifications and source traces. Tool marks includes tool identification, burglary and home invasions (Nichols, R. 2018).

1.2.3 Court testimony of Forensic Science

In terms of court testimony, expert of forensic science is considered as expert witness who has the obligation to explain the complicated scientific evidence by using specific scientific knowledge to the judge and jury and this is well known as expert testimony which helps individuals in the court of law understand the evidence (McCarthy Wilcox, A., & Nicdaeid, N. 2018).

As an expert witness of judicial system, there are few factors can influence qualification of court testimony, such as years of expert experience and training, education level, job position (accredited lab) and career certificate level (McCarthy Wilcox, A., & Nicdaeid, N. 2018). Based on McCarthy's article, work experience and training, and education level are most important elements of qualification. "Somebody . . . who has training. To me it's important to have a college background, scientific background. If you're going to be analysing data, you need to understand statistics and also processes and knowing what procedures

are and following them. Just because somebody takes a six weeks course doesn't really, to me, qualify them as an expert." (McCarthy Wilcox, A., & Nicdaeid, N. 2018).

The credibility is the other important part of expert testimony, and it can be understood as persuasive to be an expert for testimony (McCarthy Wilcox, A., & Nicdaeid, N. 2018). Brodsky et al explained that intelligence, believability, likability and trustworthiness are four primary characteristics to influence the credibility of expert witness and likability plays a significant role within these elements (Brodsky, S., Griffin, M., & Cramer, R. 2010). Additionally, McCarthy held the view that the credibility of expert witness can be affected by various factors instead of one single element (McCarthy Wilcox, A., & Nicdaeid, N. 2018).

Summary

The modern forensic science aims to apply scientific method and technology to find and analysis related evidence from crime scene and helps the court of law understand complicated scientific knowledge to deal with crime events. Obviously, forensic science includes crime scene investigation, evidence analysis and expert testimony.

For these three main bodies of forensic science, crime scene investigation is the part of collection of related evidence, which it is the fundament of next process of forensic science, evidence analysis. Furthermore, the evidence analysis focus on using scientific technology to provide certificated evidence report for judicial system which it presents as forensic expert testimony.

Chapter Two

General Introduction of Forensic Evidence

As mentioned before, forensic science is composite of crime scene investigation, forensic evidence analysis and forensic court testimony and eventually all of them aims to provide reliable and scientific evidence for the judicial system. In other works, forensic evidence is the key of forensic science from searching, collection, analysis and explanation.

In this chapter, the article will discuss what forensic evidence it is and demonstrate the factors of forensic evidence. There are two generations of forensic evidence will be involved, such as finger print, ballistic, biometric technology and DNA profile.

2.1 Introduction

In law system, the judge has the authority to confirm if the evidence can be applied in the court as "case related evidence" (Sapse, D., & Kobilinsky, L. 2011). For Anglo-American jurisdiction, once the evidence can prove statements in a case, then these types of evidences can be handled in the court for the following cases. This process is well known as case law and it helps to improve the integrity of jurisdiction by question the relatability of evidence and ordinances in variety and complex cases (Sapse, D, & Kobilinsky, L. 2011; Sapse, D., & Kobilinsky, L. 2011). Generally, this evolution comes for three aspects. The admission of evidence in the court of law, the reliability of evidence and assessment of evidence (Adam, C. 2016).

Forensic science deals with evidence from criminal cases related to legal problems (Adam, C. 2016). By analysis related evidence from criminal scene, forensic science can provide scientific results to the court of law and provide statements from criminal cases (Adam, C. 2016; Turvey, B. 2013). In other words, evidence is the target which forensic science focus on and justice system is the purpose which forensic science works for (Turvey, B. 2013).

As a result, the role of forensic science involves the reliability of evidence and assessment of evidence for law system (Adam, C. 2016). However, the first-generation evidence, second-generation

evidence are utilized in the court of the law and the can influence the justice of jurisdiction. In this part, the article will discuss scientific evidences in forensic area including three characteristics of evidence and two generations of forensic.

2.1.1 Characteristics of evidence

i) Admissibility of evidence

Admissibility of evidence means whether the evidence has enough context to the related case and whether the evidence has enough value handling to the court of law (Adam, C. 2016; Siegel, J. 2016).

ii) Reliability of evidence

Reliability of evidence in the court of law are judged as the level of reliability instead of simply answer as reliable or unreliable evidence (Adam, C. 2016). The level of evidence reliability content with the methods of scientific analysis and the result of the scientific analysis, which can help evaluate the admissibility of evidence. There is a phrase from Susan Haack as 'admissibility is categorical, reliability is continuous' (Adam, C. 2016).

iii) Assessment of evidence

Assessment of evidence represent the forensic evidence need to be analysed scientifically by expert and be communicated clearly to the court of the law (Adam, C. 2016). In this stage, forensic experts have two responsibilities, analysis and evaluate evidence by scientific method and explain the evidence based on the analysis as an expert witness. Assessment of evidence by forensic experts associate the quality of quality of reliability of evidence and assessment of evidence (Adam, C. 2016).

2.2 First generation forensic evidence

First generation forensic evidence include bite and tool marks, hair and fibre, ballistics, handwriting, voice exemplars, and fingerprints. These evidences also are regarded as physical forensic evidence showing in the court of law frequently (Murphy, E. 2007). However, the first-generation forensic evidence is cooperated evidence, since it usually be utilized with other evidences to support statement and help adjudication (Murphy, E. 2007). As a result, it is hard to make full field of criminal adjudication only based on isolated first-generation forensic evidence (Murphy, E. 2007). There are few reasons to explain this.

i) First generation forensic evidence can be applied on limited range circumstance with special situation (Murphy, E. 2007). For example, ballistics evidence only can be applied on the case related to firearms when bullets are recovered accurately or firearms are recorded at the same time.

ii) The methods to analysis first generation evidence rely on observation and experience of expert (Murphy, E. 2007). Laypeople can understand the concepts of these analysis easily, so that they also can be trained to operate these experiential and observational analysis quickly (Murphy, E. 2007).

iii) Depending on the investigate purpose, the first-generation evidence generally asks for comparison process to confirm the analysis result (Murphy, E. 2007). For instance, unknown fingerprint, hair and tool mark need to be compared with known samples to answer whether they are matching. If either unknown collection or unknown sample is missing, it is impossible to have clear analysis result (Murphy, E. 2007). In other words, the first-generation evidence cannot be utilized to target who is suspect or perpetrator, but it can be utilized to confirm from suspect to perpetrator with the help from other evidences.

iv) The first-generation evidence only can reveal limited 'surface' information of the evidence itself and it is hard to obtain further and deeper information which might have strong context with criminal cases (Murphy, E. 2007). This will significantly influence the admissibility and reliability of evidence in the court of law (Murphy, E. 2007). For example, comparison of fingerprints can answer the question of matching, but it fails to find out further information about sex, age or even health and mental situation (Murphy, E. 2007).

2.2.1 Fingerprints

Fingerprints include palm print and foot print, which it is the combination of friction ridge known as "a raised portion of the epidermis on the palmar or plantar skin, consisting of one or more connected ridge units" (Moses Daluz, H. 2014). Forensic analysis fingerprints rely on the comparison between known friction ridge of fingerprint and unknown friction ridge of fingerprints, so it is essential to record or collect fingerprints as standards (Moses Daluz, H. 2014). The known fingerprint shares the following characteristics, official record of individual identification, matching exist criminal record, compare unknown fingerprint, and collect as standard in finger identification system as data base for searching (Moses Daluz, H. 2014).

There are few different fingerprint types depending on record method, inked fingerprints, powdered fingerprint and digital fingerprint (Moses Daluz, H. 2018). Inked fingerprint is the basic way to collect fingerprint and It is collected on tenprint card by covering entire friction ridge skin with ink (Moses Daluz, H. 2018). Commonly, five fingerprints from left hand and right hand separately, flats (4 fingers

simultaneously) and palm need to be collected on tenprint card. Powdered fingerprint uses special power covering friction ridge to record the pattern instead of ink (Moses Daluz, H. 2018). Compared with inked fingerprint, the powdered one has better quality as it can show more details of friction ridge, so powdered fingerprint is the priority option to collect fingerprint. Digital fingerprint are collected live-scan equipment and the information stores in computer (Moses Daluz, H. 2018). Digital fingerprint can be regarded secondary forensic evidence as biometric technology. Digital fingerprints can be transmitted quickly depending on the analysis requirement, and also it allows to quick search in the digital data base to match known fingerprint and unknown fingerprint (Moses Daluz, H. 2018).

2.2.2 Ballistics

Forensic ballistic aims to analysis the type and calibre of the firearm from criminal case and compare the ammunition and firearms to find out the links between ammunition and firearms (Price, G. 1977). For example, one of the ballistics analysis relies on the comparison between the twist (land and groove) or polygonal boring of suspect firearm barrels and the class characteristics (landmarks) on bullet (DiMaio, V. 2015). This comparison focus on number of lands and grooves, diameter of lands and grooves, width of lands and grooves, depth of grooves, direction of rifling twist and degree of twist (DiMaio, V. 2015). Additionally, black power of base marking on bullets and shaped firing-pin mark of cartridge cases are also can be analysed to find linking ballistics evidence (DiMaio, V. 2015).

2.3 Second-generation evidence

The second-generation evidence includes DNA typing, biometric scanning and location tracking.

i) The second-generation evidence can be utilized for a wide range of criminal types (Murphy, E. 2007). For example, DNA analysis for personal identification can be applied on cases related to sex harassment, firearms situation, homicide or accident (Murphy, E. 2007).

ii) Compared with the first-generation evidence, the second-generation evidence has much more sophisticated and scientific knowledge background (Murphy, E. 2007). This gives rise to the situation that the expert who analysis criminal evidence by second generation methods has to accept specific training instead of intuitively works (Murphy, E. 2007).

iii) The second-generation evidence requires complicated analysis, so it requires complicated but also more accurate equipment to finish analysis (Murphy, E. 2007). This can help the analysis result of

forensic evidence reach a new accurate level to increase the admissibility and reliability in the court of law (Murphy, E. 2007).

iv) The second-generation evidence relies on the database collection, and this database can be established to adapt on different requirements or special situations (Murphy, E. 2007). For instance, different countries share different DNA database or forensic anthropology database to fit their different criminal environment. What is more, the second-generation evidence can help target potential suspect by searching database and also help match existed suspect (Murphy, E. 2007).

2.3.1 Biometric technology

Biometric technology is known as the statistical method of analysis biological characteristic for recognition by measuring physiological and (or) behaviour characteristics (Zhang, D., Jing, X., & Yang, J. 2006). The purpose of biometric technology is recognition which is consider as the ability to verify the positive or negative of individual identity when specific person is targeted (Zhang, D., Jing, X., & Yang, J. 2006; Jain, A., Flynn, P., & Ross, A. 2007). In order to find unique and special individual characteristic from multiple features, measurement of different features is the key of biometric technology, so that the unique characteristic or information can be extract from these features (Zhang, D., Jing, X., & Yang, J. 2006).

The physiology biometric aims to collect physiology and biology information which have special characteristics (Das, R. 2018). It includes facial feature, retain of eye, iris of eye and fingerprints and et al. Behaviour biometric catches unique behaviour features and individual activities, such as gestures, handwriting, typing and voice et al (Das, R. 2018).

Physiology method and behaviour method both collect multiple samples, but the measurement is different (Das, R. 2018). Compared with physiology biometric technology, behaviour measurement is only taken once, then the unique characteristic of this measurement can be extract from multiple samples of this individual (Das, R. 2018).

By use biometric technology for recognition, the false acceptance rate, the false rejection rate, the equal error rate, the ability to verify rate and the failure error rate need to be considered (Das, R. 2018). (1) The false acceptance rate shows the possibility of individual who has never enrol biometric information but been recognised by biometric system (Das, R. 2018). (2) The false rejection rate show the possibility that the individual information has been enrolled in the biometric system, but the biometric system still provide negative recognition of that information (Das, R. 2018). (3) The equal error rate is the possibility which the false acceptance rate equal the false acceptance rate. This is the most appropriate rate of biometric

technology for the ability of recognition (Das, R. 2018). (4) The ability to verify rate demonstrates the percentage of a population can be enrolled in the biometric system. The total number information of enrolled successfully in the system is the key point of this rate (Das, R. 2018). (5) The failure to enrol rate reflects the percentage that the number of individuals fails to enrol into the biometric system of a total population, such as the blindness and the other dysfunctional biological feature (Das, R. 2018).

i) Finger-scan technology

Finger scan technology is based on traditional human fingerprints by a digital way, so it still works on distinguishing and matching fingerprints (Jain, A., Flynn, P., & Ross, A. 2007; Das, R. 2018). This technology shares 2 techniques, minutiae-based method and correlation-based method. Minutiae method means detecting 12 of 36 minutiae points from original picture then create the minutiae map with these details to match the suspect fingerprint. However, this method highly depends on the quality of fingerprint and it is not easy to ensure high accuracy of finding minutiae. The correlation method takes advantage of the drawbacks from minutiae method, but it also asks for accurate location of correlation on the fingerprint which can be influenced by image translation and rotation. The finger-scan technology are commonly utilized as a mature biometric technology as it is low cost, accurate enough if the quality of fingerprint can be ensured, and easy to collect.

ii) Iris-scan technology

Iris scan is a high accurate biometric technology as iris carries unique personal information and different people shares unique iris information (Das, R. 2018). This can be utilized for personal identification.

In the physiology level, the colour of iris is not personal unique feature as this is designed by the DNA which can be inherited from parents (Das, R. 2018). However, some part of iris pattern is unique. Tis unique pattern forms after human embryo during the third month of fatal gestation (Das, R. 2018). What is more, the phenotype of iris's shape appears during the chaotic morphogeneisi and the process of forming the unique pattern of iris accomplishes during the first 2 years when child enhance the biological functions (Das, R. 2018).

The complete iris has 2 layers. One is called stroma, a fibrovascular tissue, and the other layer connecting with stroma is sphincter muscle which controls the expansion and contraction of pupil (Das, R. 2018). These 2 layers compose the unique pattern of iris. As a result, different individuals shares different patterns of iris for each eye and iris pattern is the unique characteristic of human physiology (Das, R. 2018).

2.3.2 DNA profile technology

Deoxyribonucleic acid (DNA) profile also in forensic area is also known as DNA fingerprint which is considered as the golden standard of biology evidence for forensic analysis (Jamieson, A., & Bader, S. 2016; Elkins, K. 2014). DNA has excellent characteristics for forensic test as it fit the most features of forensic evidence which should be unique, doesn't change over time, easy to be found and doesn't change after being left and during examination (Elkins, K. 2014).

DNA has two primary functions in geology level. Firstly, copy and transport the same genetic information between cells (Butler, J. 2005). Secondly, carry the information code which guides the protein performance (Butler, J. 2005). Individual's DNA can be found saliva (27.1%), semen stain (5.2%), blood stain (26.1%), hair (1.1%), sweat stain, bone part and other biological body fluids (Li, R. 2015). For the same individual, the DNA information from different biological materials are the same, as DNA is the basic hereditary material of human (Butler, J. 2005).

Based on the paring double-helix structure of DNA, half of the information of DNA carrying is from mother and the other half is from father (Butler, J. 2005). The normal human has 23 pairs of chromosomes including one pair of sex determining chromosome and a pair of chromosome has the same size and the same genetic information (homologous) (Butler, J. 2005). 99.7% of information in DNA molecules are the same between different individuals and 0.3% are different between individuals (Butler, J. 2005). Therefore, the 0.3% different parts are unique one which can be utilized for human identity analysis. These 0.3% DNA variations includes two types, sequence polymorphisms and length polymorphisms respectively.

The base of DNA profile aims to detect the present of genotypes at specific locations of whole DNA sequence (Houck, M. 2015). It is essential to detect the difference of alleles (the alternative genetic loci at the same position of homologous), as the present of genotype is controlled by alleles. For forensic DNA typing, the more DNA loci are compared, the more chance to find different genotypes between unrelated individuals. In other words, the same individual can be confirmed with higher confident level if tested multiple loci (location of gene) are matching as much as possible.

i) The variable number of tandem repeats (VNTRs) and the restriction fragment length polymorphism (RFLPs)

The variable number of tandem repeats (VNTRs) are original first found in eukaryotes by Britten RJ and Kohne D in 1968 (Houck, M. 2015; Butler, J. 2005). The repeated DNA sequence located at certain DNA regions, and the repeated DNA sequences are highly unique between individuals which can be utilized for forensic recognition (Sun, Z., Li, W., Xu, S., & Huang, H. 2016; Britten, R., Kohne, D., & Britten, R. 1968).

Additionally, the random repeat variant acts as inherited allele so it can be applied for personal identification and parental identification (Sun, Z., Li, W., Xu, S., & Huang, H. 2016) (https://www.ncbi.nlm.nih.gov/medgen/?term=The%20variable%20number%20of%20tandem%20repeats%20%28VNTRs%29;). Generally, these two application in forensic science comes from the two principles of VNTR analysis, identity matching and inheritance matching (Butler, J. 2005). Identity matching demonstrates that the same VNTR alleles from a specific DNA loci must match when the two samples come from the same individual (Butler, J. 2005). Inheritance matching shows one VNTR allele of an individual must match one from father side and one from mother side, as it follows the rules of inheritance (Butler, J. 2005). For the other related relationships, this match can be tracked consistently by the degree of relatedness, such as the relationship about sibling and grandparent (Butler, J. 2005).

VNTRs is one of the testing targets of restriction fragment length polymorphism (RFLPs) which was first published Dr Alec Jeffreys in 1985 VNTR can be extracted with restricted enzymes method then be analysed by RFLP (Elkins, K. 2014).

The restriction fragment length polymorphism (RFLP) is “a difference in homologous DNA sequences that can be detected by the presence of fragments of different lengths after digestion of the DNA samples in question with specific restriction endonucleases” (https://www.ncbi.nlm.nih.gov/probe/docs/techrflp/). The method of RFLP involves in fragmentation of sample DNA by restriction enzyme, agarose gel electrophoresis to separate different length of DNA fragment, transformation of membrane, hybridization of membrane and demonstration about difference of DNA fragment length (Houck, M. 2015). This method can be applied for forensic paternity test, detection of recombination rate, genetic counselling and genetic mapping.

However, this method has some limitations for forensic analysis. Firstly, it requires sufficient DNA being extracted to support analysis and it also cost 6 to 8 days to finish all analysis (Butler, J. 2005). Secondly, the DNA samples have to be completed double-link structure, which matches the requirements of restriction enzymes to cut DNA. Thirdly, the range of detecting DNA loci is limited (D17S79, D10S28, D1S7, D2S44, D5S110, D7S467, D4S139) (Butler, J. 2005).

ii) Polymerase chain reaction (PCR) based methods

Polymerase chain reaction (PCR) was discovered by Mullis in 1990 (Kary B. Mullis. 1990). Until now, it is a mature technique can be utilized in biomedical area, such as pathogens, genomic study, diagnose disease and forensic science et al. PCR is an enzymatic technique for amplify DNA fragments (Lilit Garibyan, & Nidhi Avashia. 2013; Stephenson, F. 2016; https://www.ncbi.nlm.nih.gov/probe/docs/techpcr/). PCR

technique ensures the amount of DNA product with good quality for forensic profiling by quantifying DNA (Lilit Garibyan, & Nidhi Avashia. 2013; Elkins, K. 2014). PCR allows to extract limited DNA sample from hair, blood, skin, saliva and microbes (Butler, J. 2005). The materials of PCR process include DNA polymerase (key enzyme), DNA template, nucleotides and primers (Butler, J. 2005). DNA template is the target DNA which need to be amplified. Nucleotides include adenine (A), thymine (T), cytosine (C) and guanine (G) which are foundations of DNA structures. DNA polymerase is tool enzyme to link four nucleotides together (Butler, J. 2005). The primers are specific designed DNA fragments which guide amplify process of the targeted DNA sequence from template DNA (Butler, J. 2005).

Compared with RFLPs, PCR take a few advantages. PCR allows to copy a number of targeted DNA from limited original sample (only need 0.1 -1 ng) even highly degraded samples, which it ensure to provide enough DNA for analysis (Butler, J. 2005). What is more, PCR can be improved as quantitative method known as real-time PCR and it allows to measure gene expression (Lilit Garibyan, & Nidhi Avashia. 2013; Butler, J. 2005). Additionally, the range of detected DAN loci can are wider compared with RFLP (Butler, J. 2005). However, there are also some drawbacks of PCR technique. For example, if there is error of DNA polymerase, the whole generations of amplify can be polluted (Lilit Garibyan, & Nidhi Avashia. 2013). Secondly, when primer is utilized in PCR, and this means the primer has to be designed to fit specific DNA sequences (Lilit Garibyan, & Nidhi Avashia. 2013).

a. Short tandem repeat (STR)

Short tandem repeat (STR) is a part of satellite DNA repeats units shortly ranging from 2-6 bp for multiple times at specific genetic loci (Butler, J. 2005). It can be found surrounding chromosomal centromere and different individuals have different number of repeated sequence, so it can be utilized for individual recognition (Butler, J. 2005; Houck, M. 2015).

STR is widely analysed by combining with PCR technology together, which it benefits from the smaller size of STR compared with long repeat units (hundred to thousand bases) (Butler, J. 2005). Small size allows STR can be amplified without pollution of different size amplification since “both alleles from a heterozygous individual are similar in small size” (Butler, J. 2005). What is more, STR sequence variations generally include three types (simple repeat, complex pound repeat and complex hypervariable) depending on the repeat patterns which involves in the length of repeat unit, the times of repeat and “the region with which they conform to make an incremental repeat pattern” (Butler, J. 2005).

The application of commercial kit by using multiplex polymerase chain reaction (PCR) amplification of short tandem repeat (STR) include the following basic laboratory process. (1) Extract DNA template (2) Apply Biosystems commercial kit on extracted DNA and complete AmpliTaq Gold DNA polymerase (3)

Standard DNA (4) PCR process (5) micropipettes and sterile tips (6) Nuclease-free water (7) Micro centrifuges (8) Tube rack of micro centrifuges (9) Thin-walled PCR tube rack (10) Thin-walled PCR tubes (11) Disposable gloves (12) Permanent marker (13) Vortexer (Elkins, K. 2014).

b. Single-nucleotide polymorphisms (SNPs)

The single base pare sequence at specific loci in genome is variable between different people, and this is consider as single-nucleotide polymorphisms (SNPs) (Butler, J. 2005). SNP has been applied in forensic area since 1990s and now it can be used for estimation of ethnicity, detect disease and human traits.

Compared with STR, SNP has lower general informativeness (20% to 30% of STR) and lower number of alleles every marker (STR 5-15 different alleles, SNP only 2) (Butler, J. 2005). Therefore, the preferable heterozygosity of SNP is higher than STR based on Hardy-Weinberg equilibrium (Butler, J. 2005). Furthermore, product requirement of PCR based SNP analysis is lower than PCR based STR analysis to achieve high quality analysis from degraded DNA sample. For the dead cell, it is difficult to extract good quality DNA and it is also difficult to amplify long length DNA fragments by using PCR technology. Due to the length of PCR-SNP is shorter than PCR-STR, PCT-SNP can take advantages from the situation of highly degraded DNA (Butler, J. 2005; Houck, M. 2015).

2.4 Summary

To conclusion, forensic evidence analysis relies on multiple scientific knowledge instead of isolated science knowledge, because the types of forensic evidence are various since the different crime circumstance. What is more, no matter what kind forensic evidence it is, finger print or DNA sample, reliability is first significant point for forensic evidence analysis.

Forensic science aims to provide accurate and reliable evidence to help deal with law involved issues and forensic evidence plays a primary role of forensic analysis. The characteristics of forensic evidence are associated with admissibility, reliability and assessment of evidence. In order to provide reliable analysis forensic evidence to match these three elements, the first generation evidence of forensic science including traditional finger print and ballistics have being improved to the second generation, such as biometric scan and DNA profile.

There is no denying that the development of multiple science technology enhances the range of application of forensic evidence analysis in the judicial, and also forensic science development can be noticed in the world range world including Australia and China.

Chapter Three

Forensic Science in Australia and China

Except of applying modern technology in forensic science to provide forensic evidence with high level of admissibility, reliability and assessment, the history, administration of forensic are also important for the development of forensic science. The forensic administration of forensic science should be appropriate with the local society circumstance and law system, which it gives rise to a situation that different countries have various forensic history and management strategy even the level of forensic technology is very close in the modern society.

In this chapter, we will introduce the administration of Australia forensic science and brief history and development of forensic science in China.

3.1 Introduction

Australia is a big immigration country and Chinese population is big part of total population of Australia. Relative to Australian migration statistics (Australia Government Department of Immigration and Border Protection), in 2014-2015 The Republic of China occupied the top two of the permanent migration outcomes (family stream, points tested skilled migration and Total Skill stream); the Republic of China also was the number one Country granted selected temporary visa grants (students and visitors) (Australia Government Department of Immigration and Border Protection, Australia's Migration Programme). By 2016, Chinese persons occupied 2.2% of the Australian population (Census of Population and Housing 2011 and 2016).

The above number demonstrates the important relationship between Australia and China, but it also represents the potentiality of forensic science cooperate work between two countries, especially when crime cases involves two different lay system which associated with forensic science.

As a result, it is necessary to under both Australia forensic science system and China forensic science service. This part of the article will introduce the Australia forensic facilities and general Chinese forensic history, forensic development and forensic facilities.

3.2 Forensic Science in Australia

In 1788, the first European settled in Australia, this also brought British law system (Ubelaker, D. H, 2014. PP13). As a part of British heritage, Australia shares the similar law system from the range and level of courts to jurisdictions. As a result, the Australia forensic system also related British system. Mostly, forensic science service is engaged by police as government facility for investigation and prosecution (Ubelaker, D. H, 2014. PP14).

From the famous case of Wrongful conviction of Edward Splatt in 1984 to the case Gun Alley Murder in 2005 and until recent case Inquiry into the circumstances that led to the conviction of Mr Farah Jama in 2010, Australia Forensic system has significantly improved with the development of Australia law system. (Ubelaker, D. H, 2014. PP13). This part of article will introduce currently the Australia forensic system.

3.2.1 The National Institute of Forensic Science (NIFS) and Australia New Zealand Policing Advisory Agency (ANZPAA)

In Australia, the National Institute of Forensic Science (NIFS) is a directorate within the Australia New Zealand Policing Advisory Agency (ANZPAA) (http://www.anzpaa.org.au/forensic-science/about/our-committee). The National Institute of Forensic Science (NIFS) was established in Melbourne in 1992 by the Australia Police Minister's Council as a National Common Police Service (http://www.anzpaa.org.au/forensic-science/about/our-history). In 2008, NIFS became one of three directorates of the Australian and New Zealand Policing Advisory Agency (ANZPAA) which is a part of Australia and New Zealand Police Commissioners as forecaster, advisor and facilitator for Australia and New Zealand safety (Ross Am, A. 2012). The other two directorates of ANZPAA are Strategic Services and Corporate Services respectively (Ross Am, A. 2012).

NIFS has five major obligations, co-ordination, innovation, information management, education and training and quality, following five programs to works on specific requirements of Australia forensic science (https://www.anzpaa.org.au/forensic-science/about/our-roles).

- Co-ordination

Co-ordination means have reasonability to make jurisdictional and cross-jurisdictional capacity of forensic protocols and products, and it also helps implementation support (https://www.anzpaa.org.au/forensic-science/about/our-roles). Two programs, operational capability and operational effectiveness, are under this role. The operational capability program includes investigation the specific science requirement for forensic science from Australia and New Zealand government and providing

gap analysis to inform NIFS research and innovation roadmap (https://www.anzpaa.org.au/forensic-science/about/our-roles). Overall, operational capability program focus on providing and supporting current Australia and New Zealand forensic science. The operational effectiveness program helps the improvement of forensic service based on operational capability. This program inform forensic science policy through the development of training and education materials to assist in the implementation of the National Policy for Cross-Jurisdictional Familial DNA Searching for the Investigation of Crime in Australia (https://www.anzpaa.org.au/forensic-science/about/our-roles).

- Innovative

The NIFS contributes to a creative and innovative forensic science body of knowledge, which it is the known as innovation including three programs, research and innovation strategy, capability development, and engagement and recognition (https://www.anzpaa.org.au/forensic-science/about/our-roles).

Research and innovation strategy helps introduce the edge research and technology to national and international forensic conferences. Capability development helps apply the latest forensic technology to Australia and New Zealand forensic service. Engagement and recognition works for encouraging and awarding outstanding forensic science achievement, such as John Harber Phillips Award and NIFS Best Paper Awards (https://www.anzpaa.org.au/forensic-science/about/our-roles)..

- Information management

Information management of NIFS provides opportunities to share and exchange forensic information through NIFS to enhance the forensic communication (https://www.anzpaa.org.au/forensic-science/about/our-roles).

- Education and training

Education and training of NIFS runs specific forensic science workshops depending on the needs of Australia and New Zealand forensic training, such as Senior Managers of Australia and New Zealand Forensic Laboratories (SMANZFL) which provides leadership and management practice in forensic science, improves efficient and effective use of forensic resources, contribute to police issues in the justice system and et al. Generally, this program provide opportunities to improve forensic science skills and knowledge (https://www.anzpaa.org.au/forensic-science/about/our-roles)..

- Quality

The quality is the other role of NIFS and it delivers quality assurance programs, develops standards and manage practitioner certification program (https://www.anzpaa.org.au/forensic-science/about/our-

roles). Certification program, proficiency testing program and standard program are under this role. Certification program aims to provide and develop the certification of forensic practitioner, also this program manages the Australia Forensic Field Sciences Accreditation Board (AFFSAB) which ensures forensic practitioner are valid for related forensic work and reviews examiners who fail to follow professional codes. Proficiency testing program ensures the production and delivery of the proficiency testing and provides appropriate cost saving to forensic agencies. For the standards program, it leads the development of forensic science standards and participate the application of Australia and International Standards (https://www.anzpaa.org.au/forensic-science/about/our-roles).

3.2.2 Australia New Zealand Executive Committee (ANZFEC)

The forensic services of Australia and New Zealand government are provided under the Australia New Zealand Executive Committee (ANZFEC), and also NIFS is affiliated of ANZFEC. The committee of government forensic service includes New South Wales Police Force (forensic service group), Western Australia PathWest Laboratory Medicine, Australia Federal Police (AFP) and Australia Capital Territory (ACT) Policing, Western Australia ChemCentre Forensic Science Laboratory, Forensic Science Service Tasmania (FSST), Forensic science South Australia (FSSA), Institute of Environmental Science and Research Limited (ESR), Australia Capital Territory Government Analytical Laboratory (ACTGAL), National Measurement Institute, New South Wales health Pathology (Forensic and Analytical Science Service), Northern Territory Police (Forensic Science Branch), Queensland Health (Forensic and Science Service), Queensland Police service (Forensic Scientific Group), South Australia Police (Forensic Service Branch), Tasmania Police, Victoria Police (Forensic Service Department) and Western Australia Police.

3.2.3 Forensic Science of Australia Federal Police

For Australia Federal police, forensic science and intelligence deal with the following disciplines: (https://www.afp.gov.au/what-we-do/operational-support/forensics)

- Crime scenes investigation
- Firearms identification and armoury services
- Biological and chemical criminalistics
- Identification sciences including fingerprint and facial identification
- Document sciences

- Imagery and geomatics
- Digital forensics
- Audio and video analysis
- Counter terrorism and rapid response
- Disaster victim identification
- Weapons and technical intelligence
- Forensic intelligence
- Forensic drug intelligence

3.3 Forensic Science in China

In China, the law enforcement about forensic science is different from the Australia system. According to the section 7 (Forensic Identification and Evaluation) of the Criminal Procedure Law of the People's Republic of China (2012 Amendment), the forensic analysis must follow the following articles (http://www.gov.cn/flfg/2012-03/17/content_2094354.htm).

“Article 144. It is essential to appoint or employ expert who has special knowledge of forensic identification and evaluation to explain or deal with specific issue in the case, which it helps detect and uncover the truth.

Article 145. It is necessary for forensic expert who has reasonability for related case to give common and signature after forensic analysis work.

The expert who cheats and makes false forensic analysis in the related case must bear law reasonability.

Article 146. The investigate department haves the reasonability to inform the result and common of forensic identification and evaluation to suspect and victim. The suspect and victim have the right to apply supplementary forensic analysis or renew forensic analysis.

Article. 147. The duration of forensic psychotic evaluation is not counted into the case processing time.” (The Criminal Procedure Law of the People's Republic of China, 2012 Amendment) (http://www.lawinfochina.com/display.aspx?lib=law&id=9247&CGid=#menu19)

3.3.1 General history

In China, the most well-known history of forensic work is called The Washing Away of Wrongs at middle age during the South Song dynasty approximately AD 1247 (Asen, D., & Zelin, M. 2012). The Washing Away of Wrongs is a forensic medicine collection written by Song Ci (1186 – 1249) who influenced for Chinese forensic science significantly (Asen, D. 2017). The experience of Song Ci, as an expert, created the general forensic atmosphere of ancient China. At the same time, the Washing Away of Wrongs also affect the law enforcement and political strategies for ancient China, which is not regarded as a collection of criminal cases book but as a collection of forensic textbook (Lu, G., & Needham, J. 1988).

For the forensic science in China from 1918 to 1950, Lin Ji was one of the most important forensic expert who laid the foundation of modern forensic medicine for China (Huang, R. 1992). In 1924, He published the article "The Relationship between the Regaining of consular Jurisdiction and Medical Jurisprudence" which emphasised the importance and urgency of forensic medicine to help reform the legislation, jurisdiction and administration (Huang, R. 1992). In 1930, Lin Ji established a legal medical workshop in Beijing University for education, research and case work, and the other five forensic workshops were established at different cities of China based on his advice and proposal at that time (Huang, R. 1992). In 1933, Lin Ji started the first forensic journal in China, Monthly Forensic Medicine, which articles involved law, medicine, chemistry, psychology and detection (Huang, R. 1992). Leading forensic research and education work, Lin Ji brined up the first generation of modern forensic experts in China. As a result, his forensic work was considered as the bridge between the ancient Chinese forensic science and the modern Chinese forensic science (Huang, R. 1992).

3.3.2 The development of modern forensic science

The development of forensic science in China at 21st century is significant and mature (Jiang Na. 2014). This promotion takes advantages from the development of ministry justice system. What is more, forensic science and justice system rely on each other in China, as forensic science is not only a scientific tool to deal with law issue but also a methodological way to help the promotion of justice system.

Before 2005, forensic department of police have the most authorities for forensic exam works after the criminal scene investigation by police department itself (Jiang Na. 2014). It gave rise to a situation that the analysis can be influenced police potentially. In 2005, the Decision of the Standing Committee of the National People's Congress on the admission of the Forensic Examination are applied in China, the forensic examination are divided from judicial system facing the public (Jiang Na. 2014).

During recent years, the primary reforms of forensic science in China are to establish independent forensic institution providing forensic evaluation service for prosecutor, police and lawyer and also enhance the capability of forensic exam for the forensic department of police.

There were 26624 forensic examination being counted in 2005, and this number increased significantly and ended at 2.126 million forensic examinations until 2016 (Wang, Xu, et al. 2018). Furthermore, the forensic institutions increased from 1385 in 2005 to 4750 with 53,928 forensic exports in 2016 (Wang, Xu, et al. 2018). Inspect the increased number of forensic examinations, the standardization of China also developed. Generally, the standardization has two parts, the laboratory certification and accreditation and Establishing the system of technical standards (Wang, Xu, et al. 2018). There were certificated 443 forensic laboratories and accredited 166 forensic institutions by the end of 2016 (Wang, Xu, et al. 2018). The forensic standards are 370 covering disciplines of toxicology, forensic medicine, forensic biochemistry and other forensic evidence analysis (Wang, Xu, et al. 2018).

3.3.3 Forensic Science Responsibility in China

In China, forensic science examination includes 11 arears, Forensic pathology, clinical forensic medicine, forensic psychiatry, forensic toxicology, forensic biology evidence, microscopic evidence, questioned document examination, audio and visual materials, trace evidence, digital data evidence and traffic accident analysis. There are no significant different between

- Forensic pathology

Forensic pathology focus on trauma and injury related to homicide, suicide and accident when the damage of body and nature cause of death cannot be explained by physician. The responsibility of forensic pathology is to determine the cause of the death and manner of death by using complete autopsy which include external examination and internal examination. Forensic pathology explains the nature cause of death or non-mature cause of death, which it is the essential point to help police or agency to decide the next investigation (http://www.ssfjd.com/YJZY/Info1.aspx?ID=194).

- Clinical forensic medicine

Clinical forensic medicine exam trauma and injury on live people and provide medicolegal opinion. The cases usually related to age estimation, accident, physical injury, sexual assault and other criminal assaults. It applies clinical knowledge to the needs of legal, judicial system and find the context of the administration of justice. (http://www.ssfjd.com/YJZY/Info1.aspx?ID=195)

- Forensic biology evidence

Forensic biology applies scientific protocols to analysis biological evidence, known as laboratory analysis providing biotical evidence evaluation and conclusion of criminal cases. The work focus on the identification of biological fluids, such as hair, blood, saliva, and semen, and DNA profiling for individualization (http://www.ssfjd.com/YJZY/Info1.aspx?ID=198).

- Forensic toxicology

Forensic toxicology deal with poison and drug issues to the elucidation of questions that related legal issue. Generally, forensic toxicology aims to establish poisoning as the cause of death, investigate illegal poisoning by third party, analysis the effect of poison and drugs on human behaviour and et al (http://www.ssfjd.com/YJZY/Info1.aspx?ID=197).

3.4 Summary

Even through the global concept of forensic science is similar, the forensic science systems between different countries are different, and this is due to the different law systems and different country or culture histories.

Australia follows British type but has unique ANZPAA, NIFS and SMANZFL system as forensic administration and leading. These institutes involves care work, research, funding and strategy and all belong to government. For China, government supports forensic science service in judicial system, like police forensic department, and forensic science service can be applied by the public institutions with certificate from judicial system.

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