Revelation and Science
Vol. 09, No. 01 (1440H/2019) 9-17

The Nature of Forensic Ethics in Bioanalytical Science

[1]Ibrahim A. Shogar[*], [2]Shafida Abdul Hamid, [3] Nazri Mohd Yusof
[1] Department of Computational and Theoretical Sciences, Kulliyyah of Science,
[2.] Department of Chemistry, Kulliyyah of Science,
[3] Department of Orthopedic, Kulliyyah of Medicine,
International Islamic University Malaysia
Kuantan Campus, 25200 Kuantan, Pahang Darul Makmur, Malaysia
Email: *shogar@iium.edu.my*

Abstract
The pragmatic nature of bioanalytical science, a sub-discipline of analytical chemistry, is increasingly becoming central to address the practical needs of human community. It seems very potential to play a major role in many fields of industrial, environmental and medical applications. It nevertheless, encompasses various forms of analytical chemistry, such as: bioanalysis for medical and clinical purposes, especially in the pharmaceutical industry; quality assurance in food industry and products; bioanalysis for environmental and ecosystem; and bioanalysis for forensic purposes. The practical part of all these sciences depends mainly on bioanalytical chemistry, which is based on techniques and technologies characterized by accuracy, preciseness and honesty. To harness potentials of the newly growing science of bioanalysis, thus, the analytical chemists need to address, not only matters of method and techniques, but also the ethical implications of bioanalysis, especially the forensic science. The ethical concerns are practically arising alongside with the bioanalytical science: techniques adopted, application methods, fraudulent cases, negligence, besides other problems that may jeopardize the integrity of bioanalytical science. This article focuses, especially, on the ethical aspects of forensic science which depends solely upon bioanalytical chemistry. Forensic science is concerned with using results of bioanalysis for legal purposes to draw evidences for conviction. Although there is a considerable work on forensic science, however, the ethical dimension of this science needs further investigation, especially with highlighting the technical part of bioanalytical chemistry, as aimed by this article. In the first part the article outlines, briefly, the basic issues of bioanalytical science; then it investigates in the second part the ethical implications of forensic science. The method adopted is theoretical, critic, and analytical in nature.

Keywords: *Bioanalysis, forensic evidences, ethical implications, legal community, fabrication of evidence, NAS Report.*

Abstrak
Sifat pragmatik sains bioanalisis, sub-disiplin kimia analisis, menjadi semakin penting untuk menangani keperluan praktikal kemasyarakatan. Ia sangat berpotensi sebagai peranan utama dalam kebanyakan bidang industri, alam sekitar dan aplikasi perubatan. Walau bagaimanapun, ia merangkumi pelbagai bentuk kimia analisis, seperti: bioanalisis untuk tujuan perubatan dan klinikal, terutamanya dalam industri farmaseutikal; jaminan kualiti dalam industri makanan dan produk; bioanalisis untuk alam sekitar dan ekosistem; dan bioanalisis untuk tujuan forensik. Bahagian praktikal kesemua sains ini bergantung terutamanya pada kimia bioanalisis, yang berdasarkan teknik dan teknologi yang dicirikan oleh ketepatan, keperincian dan kejujuran. Untuk memanfaatkan potensi sains bioanalisis yang baru berkembang, ahli kimia analisis perlu mengatasi bukan sahaja soal kaedah dan teknik, tetapi juga implikasi etika bioanalisis, terutama sains forensik. Kebimbangan etika secara praktikal timbul seiring dengan sains bioanalisis: teknik yang digunakan, kaedah aplikasi, kes penipuan, kecuaian, selain masalah lain yang boleh menjejaskan integriti sains bioanalisis. Penyelidikan ini menekan terutamanya, mengenai aspek etika sains forensik yang hanya bergantung kepada kimia bioanalisis. Sains forensik

**Corresponding author:*
Ibrahim Shogar,
Kulliyyah of Science, International Islamic University Malaysia (Kuantan Campus)
Email:shogar@iium.edu.my

terlibat dengan penggunaan bioanalisis untuk tujuan undang-undang bagi mendapatkan bukti sabitan. Walaupun ada pelbagai analisis sains forensik, bagaimanapun, dimensi etika bagi sains forensik ini memerlukan penyelidikan lebih lanjut, terutama dengan menonjolkan bahagian teknik kimia bioanalisis, yang ditekankan oleh penyelidikan ini. Pada bahagian pertama penyelidikan ini menggariskan, secara ringkas, isu asas sains bioanalisis; kemudian ditumpukan di bahagian kedua sebagai implikasi etika sains forensik. Kaedah yang digunakan adalah teori, kritikan, dan analisis secara semulajadi.

***Kata kunci**: Bioanalisis, bukti forensik, implikasi etika, undang-undang masyarakat, bukti perbuatan, Laporan NAS.*

Introduction

The modern progress in applied sciences has immensely served human community in various senses, but it also posted critical questions on its ethical, social, and legal implications. For instance, a poor or false report of bioanalysis on forensic case might cause the innocent person go to jail to serve time, while true offenders continue to commit crimes. Thus, the practical nature of bioanalytical science has become a suitable environment for ethical and legal questions.

The accelerating advancements of analytical chemistry throughout the last few decades have shifted attention of the academicians, researchers, and industry to this important field of analytical science which addresses the practical needs of human community, not only for academic and industrial purposes but also for environmental, medical and legal objectives. As a major sub-discipline of analytical chemistry, bioanalytical science is increasing becoming central because it enables to deal with the chemical content of biological fluids. The importance of bioanalysis has been shown by different fields of practical application, such as drug development, early disease diagnosis, life process study, food and environment safety, quality control of products, space exploration, and forensic science. As noted by some authors, bioanalysis is currently integrating multidisciplinary approach to form a new research field with fundamental practical achievements (Huangxian Ju, 2013).

The rapid and consistent growth of the analytical science, however, has posted critical questions on its ethical and legal implications. To harness potentials of the analytical science, therefore, the analytical chemists need to be aware of and to address, not only the technical issues of bioanalytical chemistry but also the ethical concerns of this important science[1].

1.0. Conceptualizing the Bioanalytical Science

Being the science of measurement, detection, and quantification of substances, the analytical chemistry has been an important field for understanding both the physical and biological components of the natural phenomena. The importance of qualitative and quantitative understanding of the world, however, can be traced back to the Divine Scriptures which were revealed since the dawn of human history. In other words, the importance of understanding balance (*Mizan*) and measurements (*Taqdir*) of the world as ascribed by God was indicated by these early documents. Reflecting the moral dimension, maintaining the balance is an ethical commitment to the entire human community, as emphasized by the Holy Scriptures (Qur`an, 55: 7-9). Supervision of standard weights is, therefore, a religious requirement[2]. The study and understanding basics of bioanalytical science, as an interdisciplinary discipline, are essential not only for analytical chemists, but also for the entire community of law enforcement process, such as lawyers, judges, and juries. This is important due to the serious moral, social and legal implications of bioanalysis, especially for forensic purposes.

1.1. Meaning and Importance of Bioanalytical Science

Bioanalysis is a sub-discipline of analytical chemistry which is concerned with the study of methods, technologies, and tools for detection, measurement and quantification of chemical content in biological fluids. It aims at developing methods and techniques for detection and measuring chemical or drug concentration in biological matrices, such as serum, plasma, blood, urine, and saliva, for various purposes[3]. The term '*bioanalysis*', according to Howard Hill, was coined in the 1970s to describe the process of quantifying drugs in biological fluids for the purposes of defining their pharmacokinetics[4]. The techniques and technologies of bioanalysis, however, further developed and used cross many disciplines where information of drug analysis in biological fluids is important, e.g., forensic science, drug abuse and therapeutic drug development. The scope of bioanalysis includes, not only drugs developed for medical purposes, but also drugs used for illicit purposes, forensic investigations and environmental concerns. (Howard Hill, 2009).

In his explanation of bioanalytical science, Howard Hill emphasizes the necessity of conceptual

clarification of this newly developing science to be differentiated clearly form other similar concepts of analytical chemistry. In this context he notes that the boundaries between analysis of drugs for the purpose of pharmacokinetics, forensic science, biomarkers, clinical chemistry and therapeutic drug monitoring are becoming increasingly blurred. He insists that, it is important to eliminate the silo mentality by cross fertilization of ideas between these different 'disciplines' while in the same time understanding the scientific and regularity drivers behind them. (Hill, Howard, 2009).

The basic purpose of bioanalytical science is to define the operating conditions, limitations, and suitability of methods and techniques for the intended purposes, and to ensure that the methods are optimized for validation. It is therefore, very important that the bioanalytical methods used are well characterised, fully validated and documented to the satisfactory standards in order to yield reliable results. (*Guideline on Bioanalytical Method Validation,* 2015).

1.2. Applications of Bioanalytical Science

Bioanalytical science, as a basic branch of analytical chemistry that concerned with the analysis of bio-substances, has various applications in practical life. Conclusions of bioanalysis can be used for different purposes, such as (i) pharmaceutical and drug development, (ii) environmental health, (iii) quality products, and (iv) forensic investigation. Forensic science is, therefore, one of the most important applications of bioanalytical science which provides evidence for correct decision making. It aims at using results of bioanalysis for legal purposes, which is a serious matter due to the fact that it may endanger life of innocent people or limit their freedom. Conviction of an innocent person due to erroneous testimony of analytical chemist in the court is a serious ethical problem. Using conclusions of bioanalytical science to answer the legal questions includes various techniques such as fingerprint analysis, DNA analysis, and analysis of firearms (ballistics)[5]. These evidences can be used for legal investigation, especially for criminal cases.

Science and technology, being a major means to understanding the world, can be used to reduce uncertainly about legal cases, whereby it facilitates the decision-making process, especially in criminal investigation cases. Thus, forensic science might be regarded as an essential part of judicial system which helps the law enforcement and application of justice. Laws of evidence are designed and intended to promote truth, equal justice, honesty, and integrity (Gil I. Sapir, 1982). The law needs science to approach the certainty and truth on events where the legal decision is needed. The scientific data is taken as evidence to resolve disputes, both in civil and criminal cases. Accordingly, the use of forensic science in legal investigation has gained popularity, across the last few decades, as an effective and powerful tool for seeking truth and justice in the court convictions. Information provided by analytical experts in the court are taken as an important evidence which can effectively help to convict those who are guilty of crimes and equally help exonerate the innocents[6]. Good law, therefore, depends on good science to deal with cases involving empirical evidence (Joelle Moreno, 1993).

The important role played by bioanalytical science in legal platform had indicated its superiority over the other traditional evidence, such as eyewitness, normal identification, confession, and informant testimony. (Donald E. Shelton, 2010). However, it has been realized that forensic science is not free of shortcomings, false data, and erroneous conclusions which lead, definitely, to wrongful convictions in the court. According to NAS Report 2009[7], the major problems of forensic science are mainly due to technical and methodological problems of analytical science, such as lack of preciseness, which contributed in posting critical ethical questions on forensic science and its applications in the court.

The second part of the proceeding discussion elucidates the ethical concerns of forensic science that arise due to two major defects in forensic science: (i) the invalidated data, i.e. false scientific evidence, and the erroneous testimony provided by forensic analyst to the court; and (ii) the wrongful application of analytic data by the court, due to misunderstanding, misinterpretation or any other reason. The first defect is the main source of the ethical problems of forensic science. It addresses moral responsibility of biochemists in fulfilling their technical commitments, which are necessary for validity and reliability of analytical science, such as accuracy and preciseness. The second defect, on the other hand, is related to the science of evidence and legal process in the court, exposing lawyers, judges, and juries to their moral obligations. Both defects emphasize the fact that forensic science is not free of problems or flaw-less, and its application in the court is in great need for careful observation[8].

2. The Ethics of Forensic Science

As a basic part of bioanalytical science, forensic science has shifted attention of scientists, industry, and jurists. Even politicians are concerned with the forensic science due to its pragmatic nature which enables to detect and understand the chemical content

of bio-objects for public health purposes as well as evidence for application of justice to maintain the social harmony and national security. Accordingly, considerable efforts have been made across the global community within the last few decades to promote the forensic science. Various measures have been proposed and organizations created to strengthen forensic science and develop the best methods for research and application of forensic science. Among many works on this topic, the NAS Report[9] might be regarded as one of the most comprehensive and dedicated efforts on the study, evaluation and improving practices of '*Forensics*' as related to legal matters, especially investigating criminal cases and probing the complicated incidents. Although considerable developments have been made across the various disciplines of forensic science, within the last two decades that followed this report, but conclusions of the report have remained substantial and its basic content is still relevant for both the bioanalysis and legal communities, beside its considerable value for academic purposes.

The report detects and highlights the technical problems of forensic science community, the ethical concerns, as well as the major problems of the legal community in applying forensic science in the court. Thus, the proceeding part of this paper focuses on NAS Report as main reference to elucidate matters related to forensic science, such as its major disciplines, and its ethical concerns. The analytical study of these issues will be emphasized by views of other authors, especially publications of the National Academy of Sciences (NAS) such as "*DNA Technology and Forensic Science*" and "*Reference Manual on Scientific Evidence*", and publications centered on NAS Report, such as works of Paul C. Giannelli. Because NAS Report was prepared for the USA Congress in 2009, the code (NAS 2009) is frequently used in the proceeding sections of this article to stand for the Report.

2.1. What is Forensic Science?

Forensic science is a discipline of bioanalysis which concerned with the application of scientific research conclusions for legal purposes. According to NAS 2009, forensic science is a multidisciplinary field of research and practice, founded on a systematic collection and analysis of relevant data. Disciplines of forensic science include physical and life sciences, forensic pathology, engineering, information technology, measurements and standards, testing and evaluation[10]. Forensic science aims at examining bioanalytical techniques for obtaining evidence found in modern crime laboratory such as DNA analysis, hair, paint, soil, glass, petroleum, products, exclusive, alcohol and drug in blood, urine, breath, and other questioned evidences (NAS 2009). Forensic science is a vital tool in approaching the truth in legal proceedings; including forensic chemistry, forensic biology, forensic anthropology, forensic medicine, forensic materials, forensic engineering, computational forensics, and any other analytical science that is used to resolve legal disputes, either in civil or criminal cases, aiming at application of justice and enforcing the law to protect the public health and national security (Evgeny Katz and Jan Halámek, Eds., 2016).

Due to its pragmatic nature, forensic science has been gaining a new momentum as tool for truth discovery with the advancements of modern science and technology. From legal perspective, the forensic science is the science of evidence. The validated knowledge of forensic science can provide an important assistance to the court to approach the truth and make the correct decision in the case. Forensic science, therefore, integrates science and law where principles of science are used for legal purposes. In this sense, forensic science connects between knowledge and justice. In other words, justice is to be established on forensic science which provides the valid and reliable data for evidence. Thus, some authors have rightfully noted that no field illustrates the evolution of science better than forensics (*Reference Manual on Scientific Evidence*, 3rd ed., 2011). The change and advancements in science and technology, according to NAS 2009, has been both systemic and scientific, therefore, an urgent and consistent development is needed to update the forensic science disciplines to ensure the reliability of data through establishing enforceable standards, and promote best practices and consistent applications. The continuous process of reforming the forensic science reduces the ethical concerns which are growing simultaneously with the rapid advancement of analytical science and technology.

2.1.1. The Major Disciplines of Forensic Science

The forensic science, according to NAS Report, encompasses a broad range of disciplines with distinctive practices. Each discipline exhibits variability of issues with regard to techniques, methods of validation, reliability, potential errors, research, and different acceptability levels. Some of these disciplines are laboratory based, e.g., nuclear and mitochondrial DNA analysis, toxicology and drug analysis and other methods that are based on expert interpretation of observed patterns, e.g., fingerprints, writing samples, toolmarks, and bite marks. Some activities of forensic science require skills and analytical expertise of individuals trained as scientists,

e.g., analytical chemists or biologists; other activities are conducted by scientists as well as by individuals trained in law enforcement, e.g., crime scene investigators, blood spatter analysts, and crime reconstruction specialists. Many processes used in the forensic science disciplines, however, are not based on a body of knowledge that recognizes the underlying limitations of the scientific principles and methodologies used for problem solving and discovery. It is therefore NAS Report suggests that it is important to focus on ways to improve, systematize, and monitor the activities and practices in the forensic science disciplines and related areas of inquiry (NAS 2009).

The process of forensic investigation involves data gathering, crime scene investigation, laboratory analysis, interpretation of tests and results, and reporting and communication with members of law enforcement and the judicial system. Accordingly, the forensic science enterprise includes crime scene investigators, crime laboratories, medical examiners private forensic laboratories, law enforcement identification units, resources such as registries and databases, professional organizations, prosecutors and defense attorneys, quality system providers, i.e., accrediting and certifying organizations, and federal other government agencies which conduct research as well as provide forensic science services and training (Marie Helen Marasa and Michelle D. Miranda, 2014).

The NAS Report notes that, advances in the forensic science disciplines serve three important purposes: (i) the rapid advancements of science and technology will assist law enforcement officials in the course of their investigations to identify perpetrators with higher reliability; (ii) further improvements in forensic science practices should reduce the occurrence of wrongful convictions, which reduces the risk that true offenders continue to commit crimes while innocent persons inappropriately serve the time; and (iii) any improvements in the forensic science disciplines will undoubtedly enhance the nation security (NAS 2009).

2.1.2. The Predominant Problems of Forensic Science

NAS Report notes that the forensic science enterprise is hindered by its extreme disaggregation marked by multiple types of practitioners with different levels of education and training and different professional cultures and standards for performance and reliance on apprentice-type training and a guild-like structure of disciplines, which work against the goal of a single forensic science profession (NAS 2009). In general, the predominant problems with forensic experts are credibility, honesty, competency, quality of work, and neutrality. The Report emphasizes that the forensic scientists must be independent neutral witnesses even if government employs them. The ethical conduct of experts is serious issue confronting the judicial system. Scientific evidence is far superior to other types of evidence, such as eyewitness identification and confusions, but it is also subject to misinterpretation. Experts' misrepresentations include lying about credentials, submitting false laboratory reports, data fabrication or tailoring testimony to fit facts determined by the investigation, misleading testimony, presenting biased testimony, and testimony based on unproven techniques. The most dangerous problems of forensic science, according to Gil I. Sapir, [1982], are those that most resemble the truth. The assessment of forensic methods and technologies, the collection and analysis of forensic data; accuracy and error rates of forensic analysis; sources of potential bias and human error in interpretation by forensic experts; and proficiency testing of forensic experts are often exposed by careful examination, and independent testing regardless of the scientific evidence being used (Gil I. Sapir, 1982).

2.2. The Ethical Implications of Forensic Science

The ethical concerns of forensic science are growing simultaneously with the rapid advancement of analytical science and analytical technology. Ethics of forensic science are the moral principles pertaining to the application of scientific knowledge for legal purpose, such as the validated honest testimony of an analytical chemist in the court. It encompasses two modes of ethics: (i) the personal ethics, i.e. moral principles that obligated by religion, culture or the personal worldview; and (ii) the professional ethics, that is moral codes and guidelines determined by the profession or specific field of work to regulate the personal conduct and maintain the integrity of the profession or the work.

Science and technology are definitely capable of providing reliable evidences for proper legal decision making. Nevertheless, the scientific evidence is often considered reliable rather than other types of evidence commonly used in the court, such as eyewitness and informant testimony. This is based on the fact that scientific evidences are precise, accurate and neutral[11]. Despite of its practical and discriminative value, some authors notes that the forensic science has not always merited the label "*scientific*" due to some technical and methodological problems (Paul C. Giannelli, 2005). The process of careful review and assessment of forensic methods and technologies has revealed that, in some cases the substantive data and testimony based on faulty forensic science analyses

which contributed in wrongful convictions of innocent people[12]. This fact has demonstrated the potential danger of giving undue weight to evidence and testimony derived from imperfect testing and analysis. Moreover, imprecise or exaggerated expert testimony has sometimes contributed to the admission of erroneous or misleading evidence (NAS 2009).

Findings of the NAS Report have concluded that a number of forensic science disciplines, forensic professionals, have yet to establish the validity of their approach or the accuracy of their conclusions. The Report also highlighted that the courts have been utterly ineffective in addressing this problem. The ineffectiveness of the court to address the problem, according to the Report, was due to a variety of reasons, including (i) the rules governing the admissibility of forensic evidence, (ii) the applicable standards governing appellate review of trial court decisions, (iii) the limitations of the adversary process, and (iv) the common lack of scientific expertise among judges and lawyers who must try to comprehend and evaluate forensic evidence. Therefore, NAS observes, the legal system is seem to be ill-equipped to correct the problems of the forensic science community (NAS 2009).

The Report obviously classified problems of forensic science, which produce the ethical problems, into two major types: (i) the technical problems which arise due to problems of scientific method, or methodological shortcomings, such as validity of the analytical method and accuracy of conclusions. This type comprises all defects of what is named by the Report as "*the problems of the forensic science community*". (ii) The second type of the problems is attributed to the judiciary system or to the court procedures and practices. It was summarized by the Report in one basic factor which is the "*ineffectiveness*" of the court to deal with the shortcomings of the forensic science community, due to many reasons as mentioned above. These two forms of defects are the basic source of all ethical concerns of this important science.

2.2.1. Ethics of Forensic Science Community

The ethical concerns of forensic science arise due to many factors related to both technical methods of forensic science community as well as practices of legal community. Forensic scientists help the judicial system which includes the law enforcement community, such as lawyers, judges, juries and others who involve in delivering justice by providing accurate results and conclusions which assist to make the right decision in the court. Hence, analytical chemists work in forensic science laboratories, assisted by the sophisticated technologies, produce the precise and reliable data (evidence) of forensic science for the court procedures. Forensic data is gathered, examined, evaluated, an interpreted to provide reliable evidence. However, with the complexity of the interactions between the scientific methodology, the principles of justice, and the realities of the practice of law and criminalistics, the ethical issues frequently arise. (Peter D. Barnett, 2001). The most revered forms of forensic science such as fingerprint identification were found to be fallible. DNA analysis is the most reliable evidence of forensic evidence, therefore it known as the "*gold standard*", but it still can lead to erroneous convictions, if the samples are contaminated, or specimens are improperly identified, or if appropriate laboratory protocols and practices are not followed (*Reference Manual on Scientific Evidence*, 3rd ed., 2011). Besides the ethical concerns which are due to the technical errors of forensic science, there are also some cases of fraud and deliberate fabrication of forensic data. Examples of these ethical problems in the forensic science community are provided as bellow:

i. Laboratory fabrication of evidence

NAS Report notes that sometimes lax standards of laboratories generate questionable or fraudulent evidence, and that which lacked quality control measures. It emphasizes that an audit by the Texas Department of Public Safety confirmed serious inadequacies in the laboratory's procedures, including "routine failure to run essential scientific controls, failure to take adequate measures to prevent contamination of samples, failure to adequately document work performed and results obtained, and routine failure to follow correct procedures for computing statistical frequencies." The Report continuous to elucidate that '*The Innocence Project*' has documented instances of both intentional and unintentional laboratory errors that have led to wrongful convictions, including: (i) contamination and mislabeling of evidence in the laboratory; (ii) information provided in forensics reports that provide conclusions from tests that were never conducted, and misinterpretation of evidence; (iii) in the courtroom presented evidence which provide a statistical exaggeration of the results of a test conducted on evidence, and providing false testimony about test results (NAS Report)..

ii. The fraud cases and lack of good data

In one publication of the National Institute of Justice, U.S.A, entitled "*The Impact of Forensic Science: Research and Development*, 2015", the authors emphasize that in crime labs across U.S, scientists and

technicians are being armed with increasingly sophisticated technologies that they can use to help bring criminals to justice and prevent the innocent from going to prison. Innovations from forensic science research and development (R&D) are bringing new techniques to crime solving and increasing the reliability and efficiency of forensic testing. Just as medical research is crucial for advancing public health, sustained progress in the research underlying forensic science is critical for advancing public safety and the administration of justice[13]. Strengthening science to improve justice is a key goal of the analytical chemists and all stakeholders of forensic science. There must be developing procedures to limit investigator bias in examining fingerprints; and creating examination standards for a variety of evidence types in criminal cases.

This ideal picture of forensic science might be a positive feedback for critical observations made earlier on forensic laboratory practices. With this concern, the NAS Report notes that although cases of fraud in forensic science appear to be rare, perhaps of more concern is the lack of good data on the accuracy of the analyses conducted in forensic science disciplines and the significant potential for bias that is present in some cases. The Report, farther, emphasizes that the failure to acknowledge uncertainty in findings is common. Cases are solved in an hour, highly technical analyses are accomplished in minutes, and laboratory and instrumental capabilities are often exaggerated, misrepresented, or entirely fabricated (NAS 2009).

2.2.2. Forensic Ethics of Legal Community

The term "legal community" in this context is used for all stakeholders of law enforcement process, including lawyers, judges, juries, testimony experts, and all agencies involve in the process of applying justice. The two problems that arise when we talk about the ethical concerns of forensic science in legal community are: (i) problems of reliability of forensic evidence which produced by experts and analytical scientists in laboratory practices. The question of reliability arises when such scientific evidences are introduced before the court because they must be based on accurate methods of analysis and precise conclusions to be free of any technical error, let alone fraud and the deliberate fabrication. Such evidence, also, must be free of misrepresentation of analytical experts in the court. (ii) The improper or erroneous application of forensic evidence by the court in specific cases; and this might occur either due to misinterpretation of scientific evidence or misunderstanding, or both. Some authors hold the view that the greater use of scientific evidence in the courtroom threatens the ability of judges and jurors to comprehend the evidence (John W. Wesley, 1984). The insufficient knowledge of legal scholars on technical reports of experts is described by NAS Report as "*The ill-equipped link between forensic science and legal system*". Lawyers and judges often have insufficient training and background in scientific methodology, and they often fail to fully comprehend the approaches employed by different forensic science disciplines and the reliability of forensic science evidence that is offered in trial. The Report observes that the forensic science system exhibits serious shortcomings in capacity and quality, yet the courts continue to rely on forensic evidence without fully understanding and addressing the limitations of different forensic science disciplines. (NAS 2009).

Accordingly, the major ethical concerns of forensic science in legal community arise about issues such as reliability of forensic evidence, expert testimony, and misinterpretation of forensic data by the court. (Millett, S., 2013). Producing fabricated forensic data is totally violates not only the ethical principles but also principles of the scientific integrity and rule of law. On the other hand, misrepresentation or misinterpretation of evidence is definitely leads to wrong conclusions and miscarriage of justice. Courts, therefore, need to examine the scientific basis of expert testimony to ensure that it meets the same rigorous standard employed by scientific researchers and practitioners outside the courtroom. (*Reference manual on scientific evidence*, 3rd ed., 2011). Critical reviewers emphasize that the forensic scientist must be able to communicate, impartially, credibly and coherently, test results and explain the methods and processes used to reach those conclusions to the court and fact-finders (Gil I. Sapir, 1982).

3. Conclusion

The various disciplines of analytical chemistry are immensely contributing to serve and satisfy the practical needs of human community and to maintain environmental health. Bioanalytical science is especially playing an important role to provide scientific evidence to legal systems for application of justice. The technological evidences provided by professional disciplines in the court are known as expert evidences. It encompasses both testimony and non-testimonial evidences, such as demonstrative evidences presented by experts. Forensic science is the application of the scientific conclusions of analytical science and technological practices for legal purposes (Paul C. Giannelli, 2005). The true value of forensic evidence emanates from accuracy and validity of its methods on one side, and

preciseness of its conclusions on the other. If forensic evidence are not objectively tested, analyzed, and interpreted by adequately trained scientists, the search for truth will potentially be compromised, if not totally distorted (NAS 2009). In order to take full advantage of scientific advancement and benefiting the power of forensic science for searching of truth, crime laboratories should be accredited, lab procedures should be standardized, and basic research needs to be conducted on many commonly used techniques. Court procedures also require improvement, in sense that courts need to examine the scientific basis of expert testimony to ensure that it meets the rigorous standard of science (Paul C. Giannelli, 2005)...

Acknowledgement

This article is part of conclusions of research project, entitled "*Review On Ethico-legal fictions of Advanced Bioengineering in the Context of Islamic Medical Philosophy*". This project is granted by IIUM Research Management Center (RMC), therefore, the authors acknowledge RMC for the financial support. The authors, also, acknowledge all writers who their valuable thoughts are benefited in this work; especially those who their texts and conclusions are cited. The authors especially acknowledge report of the National Research Council of National Academy of Sciences (NAS), entitled: "*Strengthening Forensic Science in the United States: A Path Forward*" which inspired the basic idea of the paper and supported it by useful data for analysis. We acknowledge Howard Hill (2009), Huangxian Ju (2013), Gil I. Sapir, (1982), and others for insights benefited for this work. Our thanks are due to everybody contributed in production of this paper and assisted to become a reality.

References

Donald E. Shelton (2010). *Forensic Science Evidence and Judicial Bias in Criminal Cases*. Published in Judges' Journal, Volume 49, Number 3, Summer 2010, © by the American Bar Association.

Evgeny Katz and Jan Halámek (Eds. 2016). *Forensic Science: A Multidisciplinary Approach.* (2016Wiley-VCH Verlag GmbH & Co. KGaA.- First Edition).

Gauglitz, Günter (2017). *Social Impact of Analytical Chemistry*. Anal Bioanal Chem (2017) 409:5613–5614

Gil I. Sapir**,** *Legal Aspects of Forensic Science*. Nicholas T. Kuzmack, JD, MA, author of the original chapter, "Legal Aspects of Forensic Science" contained in *Handbook of Forensic Science*,vol. l , ed. Richard Saferstein, Prentic Hall, Englewood CHFFs N.J., © 1982.

John W. Wesley, *Scientific Evidence and the Question of Judicial Capacity*, 25 Wm. & Mary L. Rev. 659 (1984), http://scholarship.law.wm.edu/wmlr/vol25/iss4/8

Joelle Anne Moreno (1993). Einstein on the Bench?: Exposing What Judges Do Not Know About Science and Using Child Abuse Cases to Improve How Courts Evaluate Scientific Evidence. *Ohio State Journal*. Vol. 64:531.

Hill, Howard (2009). *Development of Bioanalysis*: *A Short History* (Editorial). Journal 'Bioanalysis' 2009, 1 (1) pp 3-7. Future Science Ltd

Huangxian Ju, *Grand Challenges in Analytical Chemistry: Towards more Bright Eyes for Scientific Research*, *Frontiers in Chemistry*, published: 26 March 2013 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3982555/)

Marie Helen Marasa and Michelle D. Miranda (2014). *Forensic Science* (Encyclopedia of Law and Economics DOI 10.1007/978-1-4614-7883-6_11-1, Springer Science+Business Media New York 2014.

Millett, S. (2013). Ethics of Expert Evidence. *The Australian Law Journal*, Volume 87/9, September, pp 628-638.

M. Valcárcel, G. D. Christian, and R. Lucena (2013). *Teaching Social Responsibility in Analytical Chemistry* (Publications of American Chemical Society). P 6156

M. Valcárcel, G. D. Christian, and R. Lucena (2013). *Teaching Social Responsibility in Analytical Chemistry* (Publications of American Chemical Society).

Murray, R. W. *Anal. Chem*. 1994, 66, 682A−682A. (Cited from M. Valcárcel, G. D. Christian, and R. Lucena (2013). *Teaching Social Responsibility in Analytical Chemistry* (Publications of American Chemical Society)

Peter D. Barnett (2001). *Ethics in Forensic Science: Professional Standards for the Practice of Criminalistics*, CRC Press, Boca Raton, Florida, ISBN 0-8493-0860-7

Paul C. Giannelli (2005). Forensic Science. *The Journal of Law, Medicine & and Ethics*. Vol 33, Issue 3, 2005, pp 535-544.

Guideline on Bioanalytical Method Validation. Prepared by European Medicines Agency (EMEA), 2015 / CHMP / EWP / 192217 / 2009 Rev. 1 Corr. 2

The Impact of Forensic Science: Research and Development, Publications of National Institute of Justice, U.S.A Department of Justice (2015).

Article History

Received: 13-05-2019
Accepted: 11-06-2019

[1] Some authors have noted that modern analytical chemistry is dominated mainly by instrumental analysis, thus many analytical chemists are only focusing on discovery of technologies and instrument, rather than the social and ethical implications of such techniques on human and environmental health. Besides the ethical concerns, the ground-breaking discoveries of bioanalysis such as an early detection of chemical present in blood fluid that increases the risk of cancer, should be the major concern of analytical chemists.

[2] The author of "*Grand Challenges in Analytical Chemistry*", Huangxian Ju, has cited that in Bible God emphasizes that: "*A false balance is an abomination to the Lord, but a just weight is His delight*". (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3982555/)

[3] Study more in "*Guideline on Bioanalytical Method Validation*"; prepared by European Medicines Agency (EMEA), 2015 / CHMP / EWP / 192217 / 2009 Rev. 1 Corr. 2. Available at: http://www.ema.europa.eu/docs/en_GB/document_library/Scientific_guideline/2011/08/WC500109686.pdf

[4] *Pharmacokinetics*, sometimes abbreviated as PK, is a branch of pharmacology concerned with the movement of drugs within the body. It is a branch of pharmacology dedicated to determining the nature and fate of substances administered to a living organism.

[5] "*Justice Report: Improving the Practice and Use of Forensic Science A Policy Review*". Downloaded from: http://ag.ca.gov/meetings/tf/pdf/Justice_Project_Report.pdf

[6] "*Justice Report: Improving the Practice and Use of Forensic Science A Policy Review*". Available at: http://ag.ca.gov/meetings/tf/pdf/Justice_Project_Report.pdf

[7] A comprehensive study on reformation of forensic science in criminal cases was report to USA Congress in 2009 by the National Research Council of National Academy of Sciences (NAS), prepared by Committee on Identifying the Needs of the Forensic Sciences Community, entitled: "*Strengthening Forensic Science in the United States: A Path Forward*"; published by National Academies Press, USA. It become famous as 'NAS Report'. The PDF version of the Report is available at: https://www.ncjrs.gov/pdffiles1/nij/grants/228091.pdf and http://www.nap.edu/catalog/12589.html

[8] "*Justice Report: Ibid.*

[9] Recognizing that significant improvements are needed in forensic science, Congress directed the National Academy of Sciences to undertake the study that led to this report. (NAS report, p xix)

[10] The term "*forensic science*" according to NAS Report is used with regard to a broad array of activities, with the recognition that some of these activities might not have a well-developed research base, are not informed by scientific knowledge, or are not developed within the culture of science. (NAS 2009, p 39). It is obvious that the report was more focus on nature of disciplines rather than the technical definition of the term "Forensic Science". However, there are other considerable efforts on conceptual clarification of the term. See for Instance, Evgeny Katz and Jan Halámek (Eds. 2016). *Forensic Science: A Multidisciplinary Approach*. Wiley-VCH Verlag GmbH & Co. KGaA.- First Edition. PDF version available at: http://www.heraldopenaccess.us/fulltext/Forensic-Legal-&-Investigative-Sciences/Forensic-Science-Multidisciplinary-Approach.pdf

[11] When science lacks these characteristics it loses its credibility and reliability in the court.

[12] It is report that a study was conducted on 137 of the persons who have been exonerated by later DNA testing. In conducting a review of these 137 exonerees' trial transcripts, this study found invalid forensic science testimony was not just common but prevalent. This study found that 82 cases, 60% of the 137 in the study, involved invalid forensic science testimony. Find details of the full report in Donald E. Shelton (2010). *Forensic Science Evidence and Judicial Bias in Criminal Cases*. Published in Judges' Journal, Volume 49, Number 3, Summer 2010.

[13] *The Impact of Forensic Science: Research and Development*, Publications of National Institute of Justice, U.S.A Department of Justice (2015).