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Forensic casework in contemporary perspective

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Abstract: Recent developments have changed forensic casework in largely positive ways. New technology, expanded databases, enhanced statistical treatment and improved laboratory procedures enable better interpretation of evidentiary analysis and more thoughtful summaries presented in reports and testimony. Increased scrutiny has focused attention on the need for advancement in forensic science through research and structural adjustments.

Key words: forensic science, advances, new developments

When I received my PhD in 1973 from the University of Kansas my interests and training were primarily in human skeletal biology, especially the analysis of human remains from archeological contexts. However, in graduate school I had also studied forensic science and forensic anthropology with Professors William M. Bass, Thomas McKern (1920–1974), and Ellis R. Kerley (1924–1998). These teachers introduced me to casework in forensic anthropology and through lectures and seminars, the growing scientific literature supporting this work. The legendary T. D. Stewart (1901–1997) of the Smithsonian Institution served as chair of my dissertation committee. Later, I was employed by the Smithsonian and worked closely with Stewart and J. Lawrence Angel (1915–1986) on forensic issues and related research. My exposure to forensic casework increased dramatically in 1977 as a result of Angel's decision to take a sabbatical to work on a book manuscript. Angel invited me to take over his work in the analysis of forensic cases requested by the FBI laboratory in Washington D.C. At that time, the FBI laboratory was located close to the Smithsonian, facilitating collaboration in casework. When Angel returned from his sabbatical, we agreed that I would continue to handle the FBI cases since he had a substantial number of other obligations in both research and casework. My assistance to the FBI continued uninterrupted for 34 years. At this point in my career, I have formally reported on 909 forensic cases and on many occasions presented testimony in legal proceedings. This experience, spread over so many years, offers an opportunity to

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observe how the field of forensic science has changed and the new directions that continue to emerge.

Technological advances

Much of the positive change in forensic casework has been fueled by technology. The almost universal availability of high speed computers has facilitated the formation and use of large databases and sophisticated statistical analysis. Through this technology, discriminate function equations, regression analysis, three dimensional morphometrics and other approaches allow more powerful analyses and statistical rigor. Such advances enable examination of variation and the ability to present results with a sense of the associated error.

The expanding databases, formation of new documented collections and sophisticated statistical analyses reveal a great deal about human variation. Such knowledge is vitally needed to assess the error involved when a method developed from a particular sample is applied to a forensic case originating from a different one. When I first entered the field of forensic science in the early 1970's, methods developed from specific samples in North America were routinely applied to a wide variety of forensic cases with the assumption that the published errors were directly applicable. Now we know that significant human variation exists in relation to sexual dimorphism, age changes, body proportions related to the estimation of living stature, and of course, facial features related to ancestry. This knowledge urges caution in the application of data from one population to another. It also calls for the formation of regionally specific documented collections of human remains and the development of methodology specific to such collections. It likely will always remain difficult to find a method originating from a collection that represents an ideal application to particular case evidence. However, when many regional collections have been formed and studied, practitioners will have a better sense of the variation and errors involved.

Other technological developments that have fueled advancement of the forensic sciences are centered in radiologic imaging, microscopy, molecular studies, biochemical approaches and instrumentation. Advances in fluoroscopy, radiography and computed tomography (CT) imagery have enabled improved detection of structural features and more sophisticated interpretations of trauma, disease and taphonomical factors. Recent advances in magnetic resonance imaging (MRI) suggest that even more penetrating approaches may be on the future horizon. Collectively, these imaging technologies facilitate the concept of the virtual autopsy that can supplement the traditional approaches.

Microscopy has represented a useful tool in forensic analysis for decades but recent advances have allowed for improvements in documentation and the examination of trace evidence, including small particles in forensic anthropology. Scanning electron microscopy has proven to be especially useful in this regard, enabling examination and documentation of specific histological structures or small samples of evidence. A high-quality microscope with photographic documentation capability has become standard and necessary equipment in the forensic laboratory.

The many contributions of recent developments of molecular technology are well known and need little elaboration here. While the central uses of molecular approaches focus on human identification, other applications to forensic issues have emerged as well. Analysis of the amelogenin gene facilitates the estimation of sex, especially when traditional morphological evidence is not available (Baker 2009). Emerging molecular technology offers the potential to detect and diagnose specific diseases, augmenting traditional techniques employed with morphological analysis and autopsy.

Within forensic anthropology, biochemical approaches offer promise to improve methods of the estimation of age at death. Analysis of aspartic acid racemization has been utilized in this regard since the 1970s (Helfman and Bada 1975; Masters et al. 1978) with significant improvements in recent years (Ohtani 1995, Ohtani et al. 1998; Yekkala et al. 2006; Ohtani et al. 2010). Other biochemical approaches with great potential to refine age at death estimation include analyses of lead accumulation (Bercovitz and Laufer 1991; Al-Wattan and Elfawal 2010), cementum annulations (Wittwer-Backofen et al. 2004; Kasetty et al. 2010), collagen crosslinks (Walters and Eyre 1983), chemical composition of bones and teeth (Kosa et al. 1990; Ager et al. 2005), advanced glycation end products (Baynes 2001); telomere shortening in chromosomes (Takasaki et al. 2003), mitochondrial mutations (Lacan et al. 2009) and somatic rearrangement of thymus generated lymphocytes (Zubakov et al. 2010).

Advances in instrumentation have enabled more precise and quantifiable analyses, especially in such fields as forensic toxicology and chemistry. The trend toward automation has increased objectivity and reduced the likelihood of human error. Relatively new techniques have facilitated analyses that were not possible previously. Examples include recognition of bone and tooth in the analysis of very small particles using scanning electron microscopy/energy dispersive spectroscopy (Ubelaker et al. 2002) and determination of species in small bone fragments using solid-phase double-antibody radioimmunoassay (Ubelaker et al. 2004). New, more precise methods of radiocarbon analysis have contributed to estimation of date of death even in modern samples (Ubelaker et al. 2006).

Although these new technological developments have led to improvements in the applications of forensic science, recent years have also witnessed increased scrutiny and concern, primarily originating in the legal arena. These concerns have led to increased clamor for clarification of the science supporting even routine procedures in forensic practice.

Critical analysis and suggestions for advancement

In 2005, the United States Congress authorized a broad-ranging study conducted by the Washington D.C. based National Academy of Sciences (NAS) regarding forensic science. Basically, their charge was to examine many aspects of the practice of forensic science and make recommendations for improvements. The 2009 NAS report, “Strengthening Forensic Science in the United States: A Path Forward,” presented detailed information and analysis supporting 13 recommendations for improvement. These recommendations called for the following:

1. To create an independent federal entity to provide leadership and oversight.

2. To develop standards in report writing and key terminology.
3. To fund research projects, especially those aimed at documenting validity, quantification, and uncertainty and enhancing automation.
4. To increase objectivity in analysis by separating administratively laboratory functions from law enforcement or prosecutors' offices.
5. To develop procedures based on funded research to minimize bias and human error.
6. To improve tools for "measurement, validation, reliability, information sharing, and proficiency testing."
7. To develop mandatory laboratory accreditation and individual certification of practitioners.
8. To establish quality assurance and quality control programs in laboratories.
9. To establish a national code of ethics.
10. To improve education and training efforts.
11. To improve medicolegal death investigation through a variety of measures.
12. To improve fingerprint data interoperability.
13. To improve training and preparation of those involved in managing evidence.

These 13 recommendations summarized above and the detail presented to support them have fueled considerable discussion not only in Washington, D.C., but throughout the forensic science community. This discussion has led to the drafting of legislation, as well as the formation of groups created by the Executive Branch of the United States Government to address the key issues. As of this writing, laws have not yet been passed and executive orders have not been delivered, but the conversation elicited by the NAS report has demonstrated a considerable impact in the forensic science community.

Scientific working groups

In advance of the 2009 NAS report, the forensic community (through efforts of federal agencies) created discipline-specific scientific working groups aimed to establish best practices. Individual forensic working groups have been formed for anthropology, DNA analysis, document examination, friction ridge analysis, firearms and toolmarks, materials analysis, shoeprint and tire tread analysis, toxicology, gunshot residue, bloodstain pattern analysis, medicolegal death investigation, fire and explosives scene analysis, disaster victim identification, dogs and orthogonal detection guidelines, seized drugs, digital evidence, imaging technology, wildlife forensics and facial identification. These groups have met regularly to discuss issues of common concern and provide guidelines for others to follow.

Newly funded research

As soon as the NAS report became available, forensic scientists and funding agencies took notice and initiated innovative research projects directly focusing on many of the issues raised in the report. Leading the way, the National Institute of Justice (NIJ) within the Department of Justice approved 143 research awards totaling $61.3 million U.S. in the three year period between 2009 and 2011. These funds targeted DNA research and many other topics relating to the recommendations of the NAS report. Awards focused on issues of methodological advancement, new statistical approaches, methodology evaluation, new computer programs and quantification factors. Key problems addressed are uniqueness, probabilities and cognitive bias.

Summary

While these developments in the United States are both interesting and significant, forensic science is of course a global phenomenon. Many of the issues discussed above are shared with forensic scientists working in many countries throughout the world. Of course, each country has its own history, forensic problems for application, training procedures, technology availability, economic resources and internal forensic patterns of interaction. However, all practitioners share a common interest in employing the best science possible and ensuring objectivity and accuracy. Individual research advances benefit all, and can increasingly be shared through electronic access.

The practice of forensic science is substantially different today than when I initially entered the field in the early 1970s. Today, documentation and maintenance of the chain of evidence are especially important. Even if the science and interpretations are flawless, the impact of forensic work can be reduced or negated entirely if questions arise regarding contamination or improper control of evidence. This represents a primary reason why laboratory accreditation has become such an important issue. Proper accreditation procedures call attention to laboratory security and protocols that may put analysis in question. These procedures and reviews can lead to genuine improvements in quality control in the laboratory. They also can help dispel suspicion of bad practice that can affect case presentation in the legal process.

Techniques of court room presentation are much improved today. Past uses of slide projectors and drawings have been supplanted with sophisticated PowerPoint presentations and dynamic computer modeling. Such advances enable more educative and detailed testimony. However, they also invite challenges regarding accuracy and objectivity.

Scientific opinion is more likely to be challenged today. The legal community has learned to not just accept interpretation but demand statistical analysis, associated probabilities and presentation of the supportive peer-reviewed scientific literature. Judges remain the gatekeepers in the determination of who is qualified to testify and whether the science is legitimate and relative to the case. Individual certification has become increasingly important in the establishment of credibility and, as noted above, may become mandatory in the future.

Documentation of evidence and analysis has always been important, but especially so today. The documentation must be thorough and consistent with both bench notes and formal reports. Preparation for testimony has become increasingly time-consuming in anticipation of rigorous cross examination and review of the often extensive notes and documentation associated with each case.

Today, the media represents more of a factor than in the past. Judges and juries likely have been exposed to the versions of forensic science presented on television and in other fiction-oriented media. This exposure can produce misinformation and incorrect expectations that affect the legal process. Forensic scientists need to be aware of these factors and make sure they are prepared to present the correct information.

Forensic science represents a fascinating and dynamic field that continues to attract highly qualified students. Forensic casework offers scientists an opportunity to apply their knowledge and techniques to real problems of society. Through new technology, exciting research initiatives and structural improvements, progress is likely to continue globally.

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