Received: 20 June 2017 | Revised: 16 August 2017 | Accepted: 18 August 2017

DOI: 10.1002/ajpa.23306

CENTENNIAL PERSPECTIVE

WILEY American Journal of PHYSICAL ANTHROPOLOGY

A history of forensic anthropology

Douglas H. Ubelaker

Anthropology, Smithsonian Institution, NMNH MRC 112 PO Box 37012, 10th and Constitution Ave NW Washington, District of Columbia 20013-7012

Correspondence
Douglas H. Ubelaker, Anthropology, Smithsonian Institution, NMNH MRC 112 PO Box 37012, 10th and Constitution Ave NW Washington, DC 20013-7012.
Email: ubelaked@si.edu

Abstract

Forensic anthropology represents a dynamic and rapidly evolving complex discipline within anthropology and forensic science. Academic roots extend back to early European anatomists but development coalesced in the Americas through high-profile court testimony, assemblage of documented collections and focused research. Formation of the anthropology section of the American Academy of Forensic Sciences in 1972, the American Board of Forensic Anthropology in 1977/1978 and other organizational advances provided important stimuli for progress. While early pioneers concentrated on analysis of skeletonized human remains, applications today have expanded to include complex methods of search and recovery, the biomechanics of trauma interpretation, isotopic analysis related to diet and region of origin, age estimation of the living and issues related to humanitarian and human rights investigations.

KEYWORDS

forensic anthropology, history, organizational development

Forensic anthropology represents the application of the knowledge and methodology of anthropology, especially biological anthropology and archaeology, to medico-legal issues. Traditionally, the practice of forensic anthropology has focused on the recovery and analysis of human remains. This work includes not only search and recovery, but also determination if recovered evidence is bone or tooth, species representation, estimation of time since death, sex, ancestry, age at death, living stature, taphonomic history and recognition of any other features that may assist identification and detection of foul play (Blau and Ubelaker, 2016; Stewart, 1951).

In some circumstances, analysis may also include techniques of facial approximation and/or photographic superimposition (Stephan and Claes, 2016). Facial approximation is employed when remains are thought to be of recent origin but have not been identified using other methodology. The technique is used in an attempt to reach out to the public in search of investigative leads.

Photographic superimposition involves the comparison of a recovered skull with antemortem photographs of a missing person perhaps represented by the recovered remains. The technique is primarily useful for exclusion but has declined in use in favor of more accurate molecular analysis (Ubelaker, 2015).

Recently, the scope of forensic anthropology has been expanded to include issues of the living related to identification (Fenger et al., 1996; Sauer et al., 2012) and age determination (Black et al., 2010). Also, extensive research has focused on the dynamics of trauma analysis, as well as the complexities of decomposition. Trauma analysis has emerged as one of most important contributions forensic anthropologists make in the medico-legal arena.

1 | EARLY PIONEERS

Academic roots of this endeavor are closely related to those of physical anthropology, extending back to European centers of comparative anatomy (Spencer, 1982; Stewart, 1977, 1979a, 1979b; Thompson, 1982; Ubelaker, 2009). Although these early specialists may have offered opinions on medico-legal issues, recognition of formal consultation crystalized with American testimony in high-profile trials. Jeffries Wyman (1814–1874) represents a key early pioneer of forensic anthropology testimony. As noted by Stewart (1979b) Wyman held a medical degree from Harvard University and became the first Curator of the Peabody Museum of American Archaeology and Ethnology in 1866. His testimony in the trial of Harvard professor of chemistry John W. Webster, accused of the murder of Dr. George Parkman, attracted extensive media and scholarly attention. Parkman, a prominent benefactor of Harvard University had loaned money to Webster and was killed when he visited the laboratory of Webster to collect payment. When the building janitor reported the discovery of remains in Webster's toilet, authorities recovered the evidence and invited Wyman to conduct the analysis. Apparently, Webster had removed parts of the body he thought could be used for identification and

burned them. Wyman's analysis and testimony demonstrated that the burned bones represented those that had been separated.

Another 19th century murder trial brought widespread attention to anthropological testimony. In Chicago, Adolph Luetgert, a sausage producer, was accused of killing his wife and disposing of the corpse by placing it in a solution of potash in one of the factory vats. Investigation of the residue revealed small fragments that were brought to the attention of Dorsey (1868–1931) of the Field Columbian Museum (currently the Field Museum of Natural History) in Chicago. Dorsey had received his Ph.D. from Harvard in 1894 and published on themes related to physical anthropology (Dorsey, 1896, 1899). In the Luetgert trial of 1897–1898 Dorsey testified that the small fragments recovered from materials associated with the sausage vat originated from a human female. His testimony was harshly criticized by defense experts who argued that such determinations could not be made with confidence from such minimal evidence (Stewart, 1978). Subsequently, Dorsey changed his academic interests toward ethnology and government service (Ubelaker, 1999a,2016). Historically, the case is important, not only for the early forensic anthropology testimony, but also to exemplify the academic critique stimulated by the contentious forensic context. Even today, anthropologists who initially and perhaps naively venture into forensic applications realize, sometimes too late, that the courtroom is profoundly different from the classroom or academic gathering.

The murder trials discussed above represented powerful catalysts toward the development of forensic anthropology; however, the growing scientific foundation is equally important. In the legal arena, it is important that methodology represents solid, accepted scientific techniques and information. Thus, forensic applications must follow the underlying, basic research. Historically, scientific testimony related to a particular technique or body of knowledge occurs more recently than the research that it is based upon.

In this regard, Stewart (1979a, 1979b) considered Dwight (1843–1911) to be the father of American forensic anthropology. Dwight received his Harvard medical degree in 1867 and accepted a position as professor of anatomy at that institution. He pioneered an effort to assemble skeletons following anatomical dissection and use them for research to develop methodology. His publications (e.g., 1878, 1881, 1890a, 1890b, 1894a, 1894b, 1905) resulting from that effort helped build a preliminary foundation for the science of forensic anthropology and the related field of skeletal biology. Even earlier, Europeans contributed to that foundation but concentrated primarily on the estimation of living stature (Beddoe, 1888; Manouvrier, 1893; Orfila, 1821–23; Orfila & Lesuer, 1831; Pearson 1899; Rollet, 1888; Sue, 1775; Topinard, 1885).

Wilder (1864–1928) represents an early academic bridge between European and American scholarship related to forensic anthropology. Wilder had post-graduate training in Germany but subsequently became a professor of zoology at Smith College in Massachusetts (Stewart, 1982b). At Smith, Wilder published on topics related to his interests in dermatoglyphics (Wilder, 1897, 1902, 1903) but also on techniques of facial approximation. In 1918, Wilder and Wentworth published their manual on personal identification which offered an early guide with an emphasis on their interests in fingerprint analysis and facial approximation.

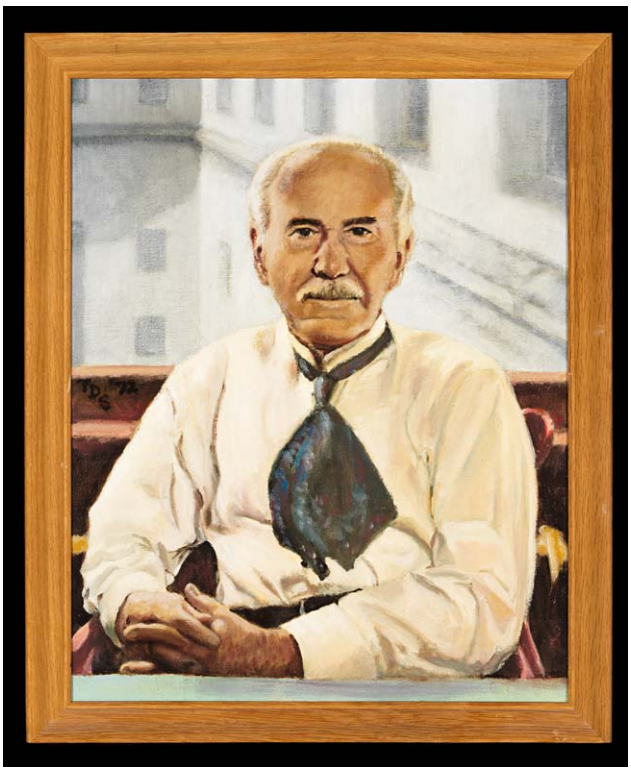

FIGURE 1 Aleš Hrdlička. Portrait by Thomas Dale Stewart. Department of Anthropology, Smithsonian Institution. Digital reproduction by James Di Loreto

2 | FBI CONSULTATION

Of course, 1918 also represents the year in which Aleš Hrdlička (1869–1943) launched the new American Journal of Physical Anthropology (Stewart, 1981). Although Stewart (1901–1997), the long-time assistant and colleague of Hrdlička, did not list forensic anthropology among his primary interests (Stewart, 1940), he did make substantial contributions (Ubelaker, 1999b, 1999c). Hrdlička (Figure 1) included "legal medicine" among his studies, researched and published on topics of broad medico-legal issues, reported on autopsies, analyzed skeletal cases, researched and testified on issues related to ancestry and consulted for the FBI in Washington, DC. In 1932, he reported on what may be the first attempt at cranial/photograph comparison in a legal context (Ubelaker, 1999b). Although these forensic efforts are minimal in comparison with his other contributions, they nevertheless place him among the early pioneers in forensic anthropology. The lack of awareness of Hrdlička's forensic work reflects sentiment at the time that forensic work was "confidential" and not a primary component of anthropological work. In the early 20th century, forensic anthropology also was not on the forefront of known forensic methodology. Although Hrdlička assisted the FBI laboratory in Washington DC with casework, anthropology was not mentioned in Hoover's article on

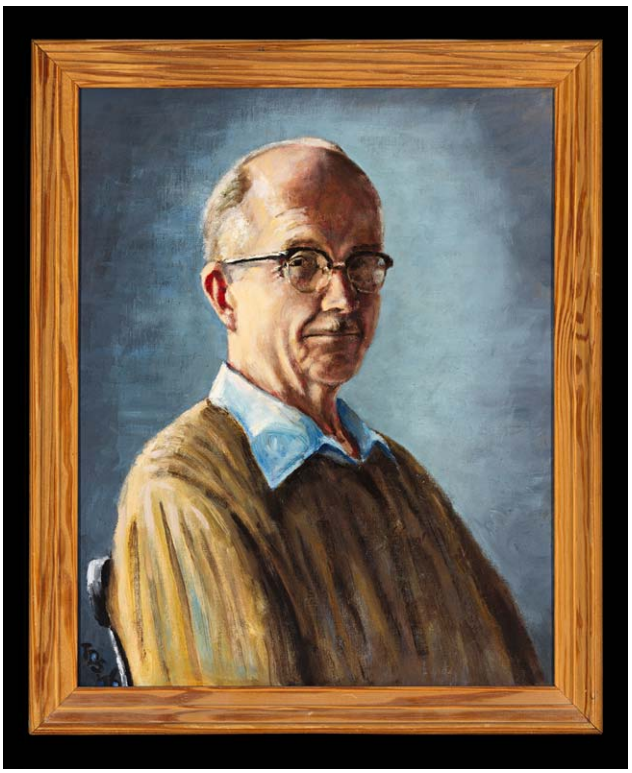

FIGURE 2 Thomas Dale Stewart, Self Portrait. Department of Anthropology, Smithsonian Institution. Digital Reproduction by James Di Loreto

"physical science in the crime detection laboratory", even though it was published by the Smithsonian Institution as late as 1940.

Hrdlička's successor at the Smithsonian, Stewart (Figure 2) continued the casework for the FBI with both greater case numbers and visibility (Ubelaker, 1999d,2000a,2014). Hrdlička had reported on 37 FBI cases between 1937 and 1943 or about 6.2 cases per year. Stewart reported on 167 cases between 1946 and 1969, a rate of 7.3 cases per year (Ubelaker, 1999d). This trend later continued at the Smithsonian when J. Lawrence Angel (1915–1986) assumed the FBI work (Ubelaker, 1989). Angel reported on at least 565 cases for the FBI and others from 1962 until 1986 (Ubelaker, 1999e). Angel also received considerable media attention for this work, greatly increasing public visibility for forensic anthropology. Ubelaker (the author) assumed responsibility for FBI case reports at the Smithsonian in about 1976, eventually reporting on over 980 cases for the FBI and others (Grisbaum and Ubelaker, 2001; Ubelaker, 2000b).

3 | KEY PUBLICATIONS

Historical advances of forensic anthropology in the 20th century are marked by landmark publications, organizational developments and new applications. In 1939, Krogman (1903–1987) published his "Guide to the Identification of Human Skeletal Material" that was widely used for analysis and identification purposes. Other key publications include Todd's study of age changes in the pubis (Todd, 1920–21), Krogman's (1962) text "The Human Skeleton in Forensic Medicine", Stewart's classic text (1979a) "Essentials of Forensic Anthropology", Trotter and Gleser's (1958) new stature formulae, Brues' (1958) article on identification and the Stewart (1970) edited volume on Personal Identification. These major publications along with many others (Buikstra et al., 2003; Dutra, 1944; Goodwin, 1978; Krogman, 1935; Snow, 1948, 1973; Stewart, 1959, 1979c, 1982a, 1984; Ubelaker, 2001, 2010, 1990, 1996, 2000c) launched the field of forensic anthropology as a major academic area within both physical anthropology and forensic science.

4 | ORGANIZATIONAL ADVANCES

In 1972, a new section of "physical anthropology" was formed within the American Academy of Forensic Sciences (AAFS). Ellis R. Kerley (1924–1998) and Clyde Snow (1928–2014) pioneered this effort, pulling together 14 anthropologists to form the new section. Historically, formation of this section has proven to represent a major stimulus in the progress of forensic anthropology. At the annual meeting of the AAFS, forensic anthropologists convene to present research results, case studies and otherwise share perspective. Recently (2015) the name was changed to "anthropology" in recognition of the broader scope of science represented, especially the inclusion of archaeologists involved in forensic search and recovery efforts. Membership in the section has grown to 536 (including all classes of membership) in 2017, reflecting growing interest in this area of applied science.

In 1977/1978 the American Board of Forensic Anthropology (2016) (ABFA) was formed, largely through the leadership of Ellis R. Kerley. This new organization offered certification for forensic anthropologists through rigorous educational and experience requirements and successful examination. Certification and diplomate status offered practicing forensic anthropologists a meaningful credential and a mechanism for those associated with the legal system to identify qualified experts. The founding ABFA group consisted of 22 forensic anthropologists.

As of 2017, 119 forensic anthropologists have been certified by the ABFA. Procedures for certification with the ABFA have evolved considerably since its formation about 40 years ago. In 2017, requirements include permanent residency of the United States, Canada or their territories, although others may petition the Board of Directors for consideration. A doctoral degree with an emphasis on physical/biological anthropology or its equivalent is required, as well as three years of experience in forensic anthropology after receipt of the degree. Letters of recommendation must include an ABFA Diplomate and originate from at least two different institutions. Applications must also include three redacted forensic case files with supporting documents. Detailed instructions are provided regarding the structure and content of submitted case files. Those qualified must successfully complete a multiple-choice and practical examination. Procedures are outlined for appeal of decisions, as well as reexamination (http://theabfa.org accessed May 29, 2017).

The Ellis R. Kerley Forensic Sciences Foundation was founded in 2000 in honor of Dr. Kerley. This foundation offers competitive scholarships to students, support for an international colleague to attend the

annual meeting of the AAFS, a best abstract award to the presenting author and a social reception for forensic anthropologists. All of these contributions have represented important stimuli for the development of forensic anthropology. In particular, the reception has provided a much-needed venue for forensic anthropologists to meet and exchange information.

For many years, Dr. Eric Baccino of France and the author organized week-long workshops in France providing both theoretical and practical training in forensic anthropology, primarily for the European scholarly community. In 2003, graduates of this training, led by Dr. Baccino formed the Forensic Anthropology Society of Europe (2017) (FASE) in association with the International Academy of Legal Medicine. This organization continues to sponsor workshops on general forensic anthropology, as well as those devoted to more advanced specialized topics.

In 2014, FASE initiated a certification program with educational and experience requirements and successful completion of examination. These initiatives have stimulated interest and involvement in forensic anthropology in Europe as well as other areas. FASE offers two levels of certification. Level 1 certification is awarded to those considered to be qualified as independent practitioner. This level requires proof of the MD or PhD in a relevant field of study, 5 years of experience after receipt of the degree and evidence of reports on at least 20 cases.

The FASE Level 2 certification requires a Master degree or the equivalent in a relevant field, as well as training and casework experience. Both levels of FASE certification require successful completion of an extensive examination. Procedures for reexamination are outlined. FASE also awards honoris causa certification for those with at least 15 years of practice who are considered worthy (http://www.forensicanthropology.eu/index.php/activities/fase-certification-process accessed May 26, 2017).

MacKinnon and Harrison (2016) provide a recent account of developments in the United Kingdom related to forensic anthropology. The primary initiative involves formation of a certification program sponsored by the Royal Anthropological Institute, the British Association of Forensic Anthropology and the Office of the Forensic Science Regulator. This UK based system offers three levels of certification, also employing education and experience requirements, as well as examination.

Latin America represents another epicenter of organizational development. The Latin American Association of Forensic Anthropology formed in 2003, bringing together practicing anthropologists from diverse organizations. This organization now offers a certification program involving education and experience requirements along with a practical examination. Meetings are held in different countries and provide a stimulating opportunity to share casework and research experience.

5 | HUMANITARIAN AND HUMAN RIGHTS

In 1984, the American Association for the Advancement of Science (AAAS) organized a delegation of forensic scientists to advise and assist families in Argentina who searched for their loved ones who had "disappeared" during the period of military dictatorship. Clyde Snow was among this group (Fondebrider, 2014). Following his retirement from the Federal Aviation Administration's Civil Aeromedical Institute (CAMI) in 1979 Snow worked as a consultant in forensic anthropology, primarily in Oklahoma and the Chicago area. The 1984 trip expanded his interests to Latin America, focusing specifically on the large numbers of individuals who had been kidnapped, killed and buried in different locations during the region's "Dirty War". Following this exploratory visit, Snow continued consultation and training with colleagues in Argentina. His efforts contributed to the founding of the Argentine Forensic Anthropology Team (EAAF) in 1984 and launched a new era of forensic anthropologist involvement in global investigations in the aftermath of political violence. The EAAF worked closely with families in the search, recovery and identification of the "missing" in Argentina. Beginning as early as 1986, they began providing their expertise and experience to assist in other countries. By 2016, Fondebrider reports that their operation included an office in New York and had provided assistance in the following countries in addition to Argentina: Angola, Bolivia, Brazil, Colombia, Côte d'Ivoire, Cyprus, Chile, Democratic Republic of the Congo, El Salvador, Ethiopia, Guatemala, Honduras, Indonesia, Kenya, Mexico, Morocco, Namibia, Panama, Paraguay, Philippines, Romania, Sierra Leone, South Africa, Sudan, Togo, Uruguay, Venezuela, and Zimbabwe. They also have worked with international efforts in Bosnia, Croatia, Georgia/Abkhazia, Haiti, Iraq, Kosovo, Peru, Philippines, and Timor-Leste.

Following the lead of the EAAF in Argentina, additional organizations and efforts have formed in many countries offering international challenges for forensic anthropologists. Physicians for Human Rights (PHR, founded in 1986), the International Criminal Tribunal for the Former Yugoslavia (created by the United Nations Security Council in 1992), the International Commission on Missing Persons (formed in 1996), the British-based organization Inforce (formed in 2001) and the International Committee of the Red Cross (ICRC) all represent major, sustained efforts aimed at recovery and identification of victims.

The International Committee of the Red Cross was established in 1863 by Henry Dunant of Geneva, Switzerland with a broad humanitarian mission. The ICRC basic humanitarian mandate is to provide impartial, neutral relief to victims of armed conflict. In 2003, the ICRC initiated forensic efforts to promote best practices in matters related to armed conflict, especially the recovery, identification and management of the deceased (Tidball-Binz, 2013). Since 2003, the growing staff and advisors of the ICRC Forensic Unit have provided leadership in many countries to forensic-related issues in need of assistance.

In addition, regionally based organizations have formed and provided expertise beyond the borders of the countries they represent. These include the Fundación de Antropología Forense de Guatemala, Centro de Antropología Forense y Ciencias Applicadas in Guatemala, Equipo Peruano de Antropología Forense, Centro Andino de Investigaciones Antropologíco Forense in Peru, the Equipo Forense Especializado in Peru, the Equipo Colombiano, Interdisciplinario de Trabajo

Forense y Asistencia Psicosocial, and the Unidad Especial de Identificación Forense of the Servicio Médico Legal in Chile (Fondebrider, 2016; MacKinnon and Harrison, 2016; Bustos Streeter and Intriago Leiva, 2015).

The U.S. Department of Defense has maintained a long-term effort to recover and identify the remains of deceased soldiers. Until 2015, this effort was led by the Joint POW/MIA Accounting Command headquartered in Hawaii. Since 2015, the initiative has been reorganized into the Defense POW/MIA Accounting Agency, also based in Hawaii. For many years, this program has employed many anthropologists in their extraordinary effort to search for, recover and identify human remains, primarily in Southeast Asia. Anthropologists involved in this effort have acquired unique experience that has led to additional training and new research.

Collectively, the organizations discussed earlier have provided many forensic anthropologists with employment and opportunities for experience in diverse situations around the world. Those involved in these efforts have developed specialized skills and methodology, dramatically broadening the scope of forensic anthropology practice.

Although growing numbers of anthropologists, including archaeologists and social anthropologists are becoming involved in forensic applications, they must learn and adapt to the legal systems context of this work. The courtroom is very different from the classroom. Likewise, the forensic report is unique and distinct from an academic term paper or manuscript aimed at publication. Those working in countries other than their own must understand the new cultural and legal context presented to them.

6 | CRITICAL ASSESSMENT OF METHODOLOGY

In 2009, the National Research Council of the National Academies of Sciences in the United States issued a report "Strengthening Forensic Science: A Path Forward." To a large extent, this report was a response to criticism of the forensic sciences and questions regarding the strength of the underlying scientific basis. Although most concern was directed toward pattern recognition areas of forensic science, such as analysis of bite-marks, blood splatter, fingerprints, ballistics and hairs and fibers, all of the forensic sciences were affected. The NAS report called for new research and a renewed effort to focus on error analysis, cognitive bias and the probabilities associated with the application of techniques and interpretation of research results. The report stimulated considerable discussion and reactions within the forensic sciences (Ubelaker, 2013), as well as funding of targeted research projects. The report and follow-up discussions encouraged the forensic sciences to explore standards and best practices that could be defended in the courtroom. This effort included development of scientific working groups that critically examined issues and attempted to define minimal standards for practice. Anthropology participated in these discussions with its own scientific working group.

In 2014, the Organization of Scientific Area Committees (OSAC) for Forensic Sciences formed within the National Institute of Standards and Technology (NIST) of the U.S. Department of Commerce. This new structure involved a central oversight group, the Forensic Science Standards Board, resource committees dealing with human factors, legal resources and quality infrastructure. The heavily populated scientific area committees and subcommittees involve many forensic scientists in most of the forensic science disciplines, including anthropology. The goal is to develop standards and guidelines for the practice of forensic science (www.nist.gov/topics/forensic-science/about-osac May 17, 2017).

Collectively, the NAS report, scientific working groups and the OSAC initiative have provided a powerful stimulus for advancement of forensic science in general and anthropology in particular. Discussions have involved a critical look at methodology, report writing, evidence security, professional qualifications, laboratory maintenance, and many other factors that relate to the quality and reliability of forensic work (Steadman, 2013). Very importantly, the discussions have led to the recognition of research needs and new experimental initiatives. The need for research and recognition of error has long been recognized (Stewart, 1953) but these new efforts may lead to improved quantification.

7 | HUMANITARIAN AND HUMAN RIGHTS RESOURCE CENTER

Scientific organizations such as the American Association of Physical Anthropologists (AAPA) and the American Academy of Forensic Sciences (AAFS) have provided an important forum for those involved in humanitarian and human rights issues to present research results and casework experience and to discuss progress with colleagues. In 2015, the AAFS took the additional step of creating a new formal program to specifically promote such involvement. The Humanitarian and Human Rights Resource Center (HHRRC) of the AAFS utilizes the assets of that organization to promote the application of the very best contemporary forensic science and forensic medicine principles to global humanitarian and/or human rights issues and projects in need of special assistance. The HHRRC provides support to AAFS members and others engaged in human rights and/or humanitarian work and encourages all to consider increased involvement in such applications. The HHRRC formed subcommittees devoted to the development of publication resources, laboratory and analysis protocols, educational materials and equipment. A key element of this new program involves monetary and equipment support to global projects in need. Proposals for support are evaluated by an International Advisory Council. Funds for support are available directly from AAFS with matching funds generously provided by the Forensic Technology Center of Excellence program of the National Institute of Justice of the United States.

Although support from the HHRRC is provided to all forensic scientists, anthropologists have been prominent in the structure of the organization, as well as recipients of support. In its first 2 years, support has been provided for the following projects that involve forensic anthropologists:

1. Preserving Evidence of the Khmer Rouge Genocide: Analysis and Conservation of the Human Skeletal Remains in Cambodia and Training of Staff.
2. Building Forensic Capacity in Forensic Archaeology and Anthropology to Help in the Identification of Human Remains, with the Participation of the Families of the Disappeared Persons at Coahuila, Mexico.
3. Application of Stable Isotope Forensics to the Identification of Unidentified Border Crossers from the Texas-Mexico Border.
4. Strengthening (Training) in the Human Identification Department of the PGJE (Procuraduria General de Justicia del Estado) in Tlaxcala, Mexico.
5. A fully Computerized Method of Osteometric Sorting for Pairwise Comparisons in Large Assemblages (Human Remains).
6. Detection of Nerve Agent Exposure from Human Bone Tissue.
7. Technical Assistance in Establishing a Forensic Laboratory within the Commission on Human Rights of the Philippines Dedicated to the Investigation of Human Rights Violations.
8. Strategies for the Identification of the 800 Victims of the Migrant Shipwreck of April 18, 2015 (Italy).
9. Operation Identification: Exhuming the Unidentified (Migrant Deaths in Texas).
10. Detecting Mass Graves: Broadening the Knowledge Base (Australia).
11. Scene Documentation for Human Rights Investigators (Training).

The projects listed above provide insight into the type of research, training and involvement currently relating to the practice of forensic anthropology in the humanitarian/human rights arena. They provide yet another example of how casework in forensic anthropology leads to new research designed to resolve issues encountered.

8 | CONCLUSIONS

The field of forensic anthropology has evolved and expanded dramatically since the early pioneers first began applying the science and methodology of anatomy and physical anthropology to medico-legal issues. Stewart's classic text "Essentials of Forensic Anthropology Especially as Developed in the United States" published in 1979 defined the field as "...that branch of physical anthropology which, for forensic purposes, deals with the identification of more or less skeletonized remains known to be, or suspect of being, human" (Stewart, 1979a:ix). While the book provided comprehensive coverage of the methodology then available to study skeletal remains, there were no chapters devoted to search and recovery and relatively little on trauma interpretation.

In 2017, forensic anthropology continues to include the type of skeletal analysis featured by Stewart in 1979. However, current practice has expanded to feature complex methods of search and recovery, exciting new research related to trauma interpretation, methods of isotopic analysis aimed at detecting diet and region of origin, age estimation of the living and contributions to the investigation of mass disasters and humanitarian and human rights issues. Today's anthropologists are sometimes requested to examine photographs and video evidence to evaluate if suspects of criminal activity might be represented (Sauer et al., 2012). Anthropological expertise is also needed to assess chronological age of individuals in relation to issues involving immigration, adoption, refugee and asylum seekers, human trafficking and child pornography (Black et al. 2010). As in other areas of forensic science, emphasis is focused on evaluations of error analysis, cognitive bias and the probabilities associated with existing methodology. Individual certification and laboratory accreditation represent growing issues that relate to the quality of analysis and testimony and evidence security. Considerable progress is registered through awareness of methodology approaches in other areas of science and adapting them to address issues in forensic anthropology.

Trauma analysis, especially relating to hard tissue, represents an area of forensic anthropology that has attracted extensive research attention and emerged as an important and primary activity of many practitioners. Through casework and innovative experimental research, forensic anthropologists have learned a great deal about the biomechanics and dynamics of traumatic injury involving bone. Calling upon their experience with both recent and ancient skeletal casework, anthropologists are uniquely positioned to differentiate perimortem (at or about the time of death) trauma that may be associated with cause and manner of death from developmental features, antemortem trauma and postmortem alterations. Assessment of the timing of an alteration demands knowledge not only of the biomechanics of bone fracture but also the skeletal remodeling system, patterns of growth and development and the many variables involved in postmortem alteration.

Understanding the decomposition process is vital to interpretations of time since death, as well as important taphonomic events and influences. Since this issue must be confronted in most forensic casework, it has attracted considerable recent attention. Through thoughtful experimentation, case experience and controlled studies in decay facilities major advances have been made in recent years. Generally, these advances document the complexity and many variables involved.

Historically, much of the development of forensic anthropology was centered in Europe and North America. Today, interest and activity in the field has expanded globally, especially in Latin America, Australia and Asia. Casework throughout the world has stimulated new research, the assemblage of documented collections and considerable academic training. These global developments have greatly improved the practice of forensic anthropology in elucidating the impact of population variation on many aspects of analysis, including age and sex estimation, but especially assessment of living stature and ancestry.

Forensic anthropology represents a challenging opportunity to apply scientific knowledge and methods to real problems of society. These problems relate not only to individual identification and assessment of foul play in criminal cases but also to global humanitarian and human rights issues. Growing numbers of students find the challenges of forensic anthropology to be compelling. This surging interest in the field is registered in the expanding numbers of student members of the

AAFS and overflowing classes in courses devoted to topics of forensic anthropology. Forensic anthropology increasingly attracts the very best and brightest students leading through graduate study to new professionals conducting much needed innovative, problem-oriented interdisciplinary research. New experimental research on key topics such as taphonomy, time since death, trauma and isotopic analysis has already produced high-impact results. Forensic anthropology has demonstrated dramatic historical development and continues to evolve to meet new demands.

ORCID

Douglas Ubelaker http://orcid.org/0000-0001-8027-2919

REFERENCES

Beddoe, J. (1888). On the Stature of the older races of England, as estimated from the long bones. *The Journal of the Anthropological Institute of Great Britain & Ireland*, *17*, 201–209.

Black S, Aggrawal A, Payne-James J. Editors. (2010). *Age Estimation in the Living: The Practitioner's Guide*. West Sussex, UK: Wiley-Blackwell.

Blau S, Ubelaker DH, Editors. (2016). *Handbook of Forensic Anthropology and Archeology. Second Edition. World Archaeological Congress Research Handbooks in Archeology*. New York: Routledge.

Brues, A. M. (1958). Identification of Skeletal Remains. *The Journal of Criminal Law, Criminology and Police Science*, *48*, 551–563.

Buikstra, J. E., King, J. L., & Nystrom, K. C. (2003). Rare but exquisite gems: forensic anthropology and bioarcheology. *The American Anthropologist*, *105*, 38–52.

Bustos Streeter, P., & Intriago-Leiva, M. (2015). The chilean forensic medical service. In D. H. Ubelaker (Ed.), *The global practice of forensic science* (pp. 39–47). West Sussex, UK: Wiley-Blackwell.

Dorsey, G. A. (1896). The history of the study of anthropology in Harvard University. *The Denison Quarterly*, *4*, 77–97.

Dorsey, G. A. (1899). The skeleton in medico-legal anatomy. Paper presented to the Medico-Legal Society of Chicago, Chicago, 1898. *In Chicago Medical Recorder*, *16*, 172–179.

Dutra, F. R. (1944). Identification of Person and Determination of Cause of Death from Skeletal Remains. *Archives of Pathology*, *38*, 339–349.

Dwight, T. (1878). *The identification of the human skeleton: a medico-legal study*. Boston, MA: David Clapp & Son.

Dwight, T. (1881). The Sternum as an index of sex, height, and age. *Journal of Anatomy & Physiology*, *15*, 327–330.

Dwight, T. (1890a). The closure of the cranial sutures as a sign of age. *Boston Medical and Surgical Journal*, *122*, 389–392.

Dwight, T. (1890b). The sternum as an index of sex, height and age. *Journal of Anat. Physiol*, *24*, 527–535.

Dwight, T. (1894a). Methods of estimating the height from parts of the skeleton. *Medical Records in New York*, *46*, 293–296.

Dwight, T. (1894b). The range and significance of variations in the human skeleton. *Boston Medical & Surgical Journal*, *1*, 73–76.

Dwight, T. (1905). The size of the auricular surfaces of the long bones as a characteristic of sex: an anthropological study. *Ameican Journal of Anatomy*, *4*, 19–31.

Fenger, S. M., Ubelaker, D. H., & Rubinstein, D. (1996). Identification of workers' compensation fraud through radiographic comparison. *Journal of Forensic Identification*, *46*, 418–431.

Fondebrider, L. (2014). Snow, Clyde C. In C. Smith (Ed.). *Encyclopedia of global archaeology* (Vol. *10*, pp. 6732–6734). New York, NY: Springer Reference.

Fondebrider, L. (2016). The application of forensic anthropology to the investigation of cases of political violence: perspectives from South America. In S. Blau & D. H. Ubelaker (Eds.). *Handbook of forensic anthropology and archaeology, second edition. World archaeological congress research handbooks in archaeology* (pp. 65–74). New York: Routledge.

Forensic Antroplogy Society of Europe. (2017). http://www.forensicanthropolgy.eu/index.php/activities/fase-certification-process. Accessed May 26, 2017.

Goodwin, R. C. (1978). The history and development of osteology in the caribbean area. *Tevista/Review Interamericana*, *8*, 463–493.

Grisbaum, G. A., & Ubelaker, D. H. (2001). An Analysis of Forensic Anthropology Cases Submitted to the Smithsonian Institution by the Federal Bureau of Investigation from 1962–1994. Smithsonian Contributions to Anthropology 45. Washington, DC: Smithsonian Institution Press.

Hoover, J. E. (1940). Physical science in the crime detection laboratory. *Smithsonian Report for 1939 3561*, 215–222.

Krogman, W. M. (1935). Missing teeth in skulls and dental caries. *American Journal of Physical Anthropology*, *20*, 43–49.

Krogman, W. M. (1939). A guide to the identification of human skeletal material. *FBI Law Enforcement Bulletin*, *8*, 3–31.

Krogman, W. M. (1962). The human skeleton in forensic medicine. *American Journal of Physical Anthropology*, *20*, 227–229.

MacKinnon, G., & Harrison, K. (2016). Forensic anthropology and archeology in the United Kingdom: Are we nearly there yet? In S. Blau & D. H. Ubelaker (Eds.), *Handbook of forensic anthropology and archaeology, second edition. World archeological congress research handbooks in archeology* (pp. 13–26). New York: Routledge.

Manouvrier, L. (1893). La determination de la taille d'après les grands os des membres. *Extrait de Memoires de la Societé d'Anthropologie de Paris*, *4*, 347–402.

National Research Council. (2009). *Strengthening forensic science in the United States: a path forward*. Washington, DC: The National Academies Press.

NIST. (2017). About OSAC. In: National Institute of Standards and Technology. Retrieved May 17, 2016, from https://www.nist.gov/topics/forensic-science/about-osac

Orfila, M. J. B. (1821–23). *Leçons de Médicine Légale* (2 vols). Paris.

Orfila, M. J. B., & Lesueur, O. (1831). Traite´ des exhumation juridique. Conside´rations sur les changemens physiques que les cadavres e´prouvent en se pourrissant dans la terre, dans l'eau, dans les fosses d'aisance et dans le fumier (Vol. 2). Paris: Béchet Jeune.

Pearson, K. (1899). Mathematical contributions to the theory of evolution. -V. On the reconstruction of the stature of prehistoric races. *Philosophical Transactions of the Royal Society of London. Series A. Containing Papers of a Mathematical or Physical Character*, *192*, 169–244.

Rollet, E. (1888). De la mensuration des os longs des membres dans ses rapports avec l'anthropologie, la clinique et la médecine judiciaire. *D'Anthropologie Criminelle Et Des Sciences Penales*. Paris, France.

Sauer, N. J., Michael, A. R., & Fenton, T. W. (2012). Human identification using skull-photo superimposition and forensic image comparison. In D. C. Dirkmaat (Ed.), *A companion to forensic anthropology* (pp. 432–446). West Sussex, UK: Wiley-Blackwell.

Snow, C. E. (1948). The identification of the unknown war dead. *American Journal of Physical Anthropology*, *6*, 323–328.

Snow, C. C. (1973). Forensic anthropology. In A. Redfield (Ed.), *Anthropology beyond the university* (pp. 4–17). Athens University of Georgia Press; Southern Anthropological Society.

Spencer F, Editor. (1982). *A history of american physical anthropology 1930–1980*. New York: Academic Press.

Steadman, D. W. (2013). The places we will go: paths forward in forensic anthropology. In D. H. Ubelaker (Ed.),*Forensic science: Current issues, future directions* (pp. 131–151). West Sussex, UK: Wiley-Blackwell.

Stephan, C. N., & Claes, P. (2016). Craniofacial identification: Techniques of facial approximation and craniofacial superimposition. In S. Blau & D. H. Ubelaker(Eds.), *Handbook of forensic anthropology and archaeology* (pp. 304–321). New York: Wiley-Blackwell.

Stewart, T. D. (1940). The life and writings of Dr. Aleš Hrdlička (1869–1939). *American Journal of Physical Anthropology*, *26*, 3–40.

Stewart, T. D. (1951). What the bones tell. *FBI Law Enforcement Bulletin*, *20*, 1–5. Reprinted in Lab Dig 1951;14(12):5–8; VA Trooper 1952;6) 7):25–29; Aust Polic J 1952;6(4):262–267.)

Stewart, T. D. (1953). Research in human identification. *Science*, *118*, 3.

Stewart, T. D. (1959). Bear paw remains closely resemble human bones. *FBI Law Enforcement Bulletin*, *28*, 18–21.

Stewart TD, editor. (1970). *Personal identification in mass disasters*. Washington, DC: Smithsonian Institution.

Stewart, T. D., (1977). History of Physical Anthropology. In A. F. C. Wallace et al (Eds.), *Perspectives on anthropology*, *1976* (pp. 70–79). Special Publication No 10. Washington, DC: American Anthropological Association.

Stewart, T. D. (1978). George A. Dorsey's Role in the luetgert case: A significant episode in the history of forensic anthropology. *Journal of Forensic Science*, *23*, 786–791.

Stewart, T. D. (1979a). *Essentials of forensic anthropology, especially as developed in the United States*. Spingfield, IL: Charles C. Thomas.

Stewart, T. D. (1979b). A tribute to the French Forensic anthropologist georges fully (1926–1973). *Journal of Forensic Sciences*, *24*, 916–924.

Stewart, T. D. (1979c). Forensic anthropology. In W. Goldschmidt (Ed). *The uses of anthropology* (pp. 169–183). Special Publication No 11. Washington, DC: American Anthropological Association.

Stewart, T. D. (1981). Aleš Hrdlička, 1869–1943. *American Journal of Physical Anthropology*, *56*, 347–351.

Stewart, T. D. (1982a). Background of American forensic anthropology. *Criminal Justice Review*, *7*, 4–7.

Stewart, T. D. (1982b). Pioneer contributions of harris Hawthorne Wilder, Ph.D., to forensic sciences. *Journal of Forensic Sciences*, *27*, 754–762.

Stewart, T. D. (1984). Perspective on the reporting of forensic cases. In T. A. Rathburn & J. E. Buikstra (Eds.), *Human identification: Case studies in forensic anthropology* (pp. 15–18). Springfield, IL: Charles C. Thomas.

Sue, M. (1755). Sur les proportions des squelette de homme, examiné depuis l'âge le plus tendre, jusqu' á celui de vingt-cinq, soixante ans, & au delá. Académie des Sciences (Vol. *2*, pp. 572–585). Paris: Mémoires de Mathematique, et de Physique, Présentés par Divers Savants et lûs dan ses assemblées.

The American Board of Forensic Anthropology. (2016). http://theabfa.org Accessed May 29, 2017.

Thompson, D. D. (1982). Forensic anthropology. In F. Spencer (Ed.), *A history of american physical anthropology 1930–1980* (pp. 357–369). New York: Academic Press.

Tidball-Binz, M. (2013). Global forensic science and the search for the dead and missing from armed conflict: the perspective of the international committee of the red cross. In D. H. Ubelaker (Ed.), *Forensic science, current issues, future directions* (pp. 337–365). West Sussex, UK: Wiley-Blackwell.

Todd, W. (1920–21). Age changes in the pubic bone. *American Journal Physical Anthropology*, *3*, 285–334.

Topinard, P. (1885). Procédé de mensuration des os longs, dans le but de reconstituer la taille. *Bulletins de la Société d'anthropologie de Paris*, *8*, 73–83.

Trotter, M., & Gleser, G. C. (1958). A re-evaluation of the estimation of stature based on measurements of stature taken during life and of long bones after death. *American Journal of Physical Anthropology*, *47*, 355–356.

Ubelaker, D. H. (1989). J. Lawrence Angel, 1915–1986. *American Antique*, *54*, 5–8.

Ubelaker, D. H. (1990). J. Lawrence Angel and the development of forensic anthropology in the United States. In J. W. Buikstra (Ed.), *A life in science: Papers in honor of J. Lawrence angel* (pp. 191–200). Kampsville, Illinois: Center for American Archaeology.

Ubelaker, D. H. (1996). Skeletons Testify: Anthropology in Forensic Science. Presented at the AAPA Luncheon Address: April 12, 1996. *Yearbook of Physical Anthropology 39*: 229–244.

Ubelaker, D. H. (1999a). Dorsey, George Amos. *American National Biography*, *6*, 764–765.

Ubelaker, D. H. (1999b). Aleš Hrdlička's Role in the History of Forensic Anthropology. *Journal Forensic Science*, *44*, 724–730.

Ubelaker, D. H. (1999c). The Legacy of Aleš Hrdlička in Smithsonian Forensic Anthropology. IVth International Anthropological Congress of Aleš Hrdlička, World Anthropology at the Turn of the Centuries, *160*: 17–21.

Ubelaker, D. H. (1999d). The forensic anthropology legacy of T. Dale Stewart (1901–1997). *Journal of Forensic Science*, *45*, 245–252.

Ubelaker, D. H. (1999e). Angel, John Lawrence. *American National Biography*, *1*, 518–519.

Ubelaker, D. H. (2000a). T. Dale Stewart's perspective on his career as a forensic anthropologist at the Smithsonian. *Journal of Forensic Science*, *45*, 269–278.

Ubelaker, D. H. (2000b). A History of Smithsonian-FBI collaboration in forensic anthropology, especially in regard to facial imagery. *Forensic Science Communications*, 2.

Ubelaker, D. H. (2000c). Publications of T. Dale Stewart (1901–1997). *Journal of Forensic Science*, *45*, 279–290.

Ubelaker, D. H. (2001). Contributions of Elllis R. Kerley to forensic anthropology. *Journal of Forensic Science*, *46*, 773–776.

Ubelaker, D. H. (2009). Historical development of forensic anthropology: Perspective from the United States. In S. Blau & D. H. Ubelaker (Eds.) *Handbook of forensic anthropology and archaeology* (pp. 76–86). Walnut Creek, CA: Left Coast Press, Inc.

Ubelaker, D. H. (2010). A history of methodology in the estimation of age at death from the skeleton. In K. E. Latham & M. Finnegan (Eds.), *Age estimation of the human skeleton* (xvii–xxv). Springfield, IL: Charles C. Thomas.

Ubelaker DH, editor. (2013). *Forensic science: Current issues, future directions*. West Sussex, UK: Wiley-Blackwell.

Ubelaker, D. H. (2014). Stewart, T. Dale. *Encyclopedia of Global Archaeology*, *10*: 7054–7056.

Ubelaker, D. H. (2015). Craniofacial superimposition: historical review and current issues. *Journal of Forensic Science*, *60*, 1412–1419.

Ubelaker, D. H. (2016). Historical development of forensic anthropology: Perspectives from the United States. In S. Blau & D. H. Ubelaker (Eds.), *Handbook of forensic anthropology and archaeology*. *World archaeological congress research handbooks in archaeology* (pp. 94–106). New York: Routledge.

Wilder, H. H. (1897). On the disposition of the epidermic folds upon the palms and soles of primates. *Anatomischer Anzeiger*, *13*, 250–256.

Wilder, H. H. (1902). Scientific palmistry. *Popular Science Monthly*, *62*, 41–54.

Wilder, H. H. (1903). Palm and sole impressions and their use for purposes of personal identification. *Popular Science Monthly*, *63*, 385–410.

Wilder, H. H., & Wentworth, B. (1918). *Personal identification: Methods for the identification of individuals, living or dead* (pp. 96–110). Boston, MA: The Gorham Press.

How to cite this article: Ubelaker DH. A history of forensic anthropology. *Am J Phys Anthropol*. 2018;165:915–923. https://doi.org/10.1002/ajpa.23306