THE ACCURACY OF THE BIOLOGICAL PROFILE IN CASEWORK: AN ANALYSIS OF FORENSIC ANTHROPOLOGY REPORTS IN THREE MEDICAL EXAMINERS’ OFFICES

Hillary Renee Parsons

University of Tennessee, Knoxville, hparson3@vols.utk.edu

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I am submitting herewith a dissertation written by Hillary Renee Parsons entitled "THE ACCURACY OF THE BIOLOGICAL PROFILE IN CASEWORK: AN ANALYSIS OF FORENSIC ANTHROPOLOGY REPORTS IN THREE MEDICAL EXAMINERS' OFFICES." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Anthropology.

Amy Z. Mundorff, Major Professor

We have read this dissertation and recommend its acceptance:

Dawnie W. Steadman, Benjamin M. Auerbach, Darinka P. Mileusnic

Accepted for the Council:

Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)
THE ACCURACY OF THE BIOLOGICAL PROFILE IN CASEWORK: AN ANALYSIS OF FORENSIC ANTHROPOLOGY REPORTS IN THREE MEDICAL EXAMINERS’ OFFICES

A Dissertation Presented for the Doctor of Philosophy Degree
The University of Tennessee, Knoxville

Hillary Renee Parsons
May 2017
ACKNOWLEDGEMENTS

Words alone cannot express my sincere gratitude to all the people who have supported me during the construction of this dissertation. I would like to take the opportunity to recognize the following mentors, friends, and family.

First, I would like to thank my committee members for their efforts and guidance in my graduate education and their influence on this dissertation. I am forever grateful for the contributions of my advisor, Dr. Amy Mundorff who has provided much needed confidence, encouragement, and an unwavering commitment to my success. Her experiences as a forensic practitioner and as an accomplished academic have not only influenced my research, but have inspired me in my own career. I look forward to future collaborations and many years of friendship. I would also like to thank Dr. Dawnie Steadman for pushing me, challenging my perspectives, and encouraging me to find my own path. She is an exemplarily professional, someone I look up to, and I am honored to have had the opportunity to work with her. I met Dr. Benjamin Auerbach when I interviewed for a spot in the graduate program, and luckily, he got stuck with me to the very end! I have been significantly influenced by his teachings and it was an honor to be his anatomy TA for three years. I sincerely thank Dr. Darinka Mileusnic for her interest in my project and the unique perspective she brings to this work. Furthermore, her encouragement and enthusiasm will never be forgotten. I would also like to thank Dr. Graciela Cabana for her thoughtful insight and guidance that helped lead me to this topic. She has had a tremendous influence on my education particularly with complex topics of DNA, race, and ancestry and I am eternally grateful for everything she has
taught me. I am honored to have had all these wonderful mentors and I cannot thank them enough.

I would also like to take the opportunity to thank a number of professionals who helped make this dissertation possible. Many thanks to Dr. Barbara Sampson, Dr. Bradley Adams, and Dr. Benjamin Figueroa at the New York City Office of Chief Medical Examiner; Dr. Luis Sanchez, Dr. Christian Crowder, Dr. Deborah Pinto, and Dr. Sharon Derrick at the Harris County Institute of Forensic Science; and finally Dr. Gregory Hess and Dr. Bruce Anderson at the Pima County Office of the Medical Examiner. Many thanks for granting me access to the casework examined in this analysis and for answering the insufferable number of questions I have asked. Additionally, I would like to extend thanks for their hospitality and their genuine interest in my project.

I am honored to have forged lasting friendships during my time in Knoxville and there is simply not enough space to properly thank everyone. To my friends and esteemed colleagues, thank you for all the good times and great laughs, may we always remain friends! Frankie West and Nicole Reeves, we have been together from the beginning and I cannot imagine what life in Knoxville would have been without you. We have been through so much and I can't wait for more as we look forward to the next chapters of our lives. I also want to thank my hometown girls Brenda Vandyke Sweeney, Beth Orser-Clementich, and Noah Massey for being my lifelong friends. You girls have never given up on me no matter where in the world I am.

I would also like to extend special thanks to my parents. I have always been the independent one, rarely seeking help or advice on many matters in my life; they let me
do my thing, and they let me do it my way. But no matter what, they have been there for me and always believed I would accomplish my goals. Finally, to my partner Owen Lang who has had tremendous patience throughout this process. Thank you for your encouragement and endless support.
ABSTRACT

This dissertation examines the accuracy of the biological profile from forensic anthropology reports among 204 resolved and 284 unresolved skeletal cases at the medical examiners’ offices in New York City, NY; Harris County, TX; and Pima County, AZ. Current forensic anthropological methods used to estimate the biological profile are developed from skeletal reference collections conferring variable degrees of accuracy. Evolving standards for evidence and expert witness testimony have ushered in an era of robust statistical validation for forensic methods, yet accuracy rates are unknown in anthropological casework. Considering 40,000 sets of unidentified human remains persist in medical examiner’s offices in the United States, the purpose of this project is to provide the medicolegal community with vital statistics regarding the accuracy of the biological profile and identify trends among unresolved cases.

Ancillary to this goal is to identify inconsistencies between the antemortem reporting process and the results gleaned from the biological profile. Results suggest that antemortem descriptions of race are inconsistent with biological estimations of ancestry and efforts to improve antemortem descriptions of the missing should be pursued.

Results of the present study suggest the biological profile confers varying levels of accuracy among resolved casework. First, estimations of sex were correct in 100% of cases, ancestry estimation were correct in 99% of cases, age was correct in 89% of cases, and stature was correct in 73% of cases. Second, FORDISC was incorrect in 64% of resolved cases with 93% of those cases involving the Hispanic category. Third,
antemortem stature records were largely absent suggesting stature has limited importance in resolving missing persons cases. Results also revealed a significant difference between the amounts of skeletal remains available for analysis among resolved and unresolved cases.

Overall, these results show that the biological profile performs well in resolved casework, but stature performs poorly for Hispanic individuals and also does not appear to be an important factor in identifications. Further, changes should be made in the missing persons reporting process to help accurately identify the race and ancestry of the missing.
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CHAPTER ONE

INTRODUCTION

This dissertation examines the contributions of anthropological reports in the resolution of missing persons' cases from the medical examiners offices in New York City, New York; Pima County, Arizona; and Harris County, Texas. To date, there have been no comprehensive examinations of forensic anthropological methods in casework; rather emphasis has been placed on validation studies administered by the academic community. Academic validation studies have increased in recent years in response to the 2009 National Academy of Science's (NAS) report titled, “Strengthening Forensic Sciences in the United States: A Path Forward.” The NAS report recommends that scientific studies evaluate the accuracy and reliability of forensic techniques and reflect actual practice on realistic scenarios. Unfortunately, validation studies conducted in the forensic anthropological community do not reflect forensic casework where multiple methods are typically employed; rather these studies tend to examine forensic anthropological methods in isolation and tested on limited sample populations. The medicolegal community relies on the expertise of forensic scientists to resolve casework and provide answers to families of the missing. Often, skeletal analysis assists the investigation of unknown remains. In these cases, the forensic anthropologist may be asked to distinguish population-level biological characteristics, recognize unique identifying features, interpret the etiology of bone trauma, and
estimate the postmortem interval, if possible. Forensic anthropologists use a variety of methods to make identifications, including radiographic analysis. A basic investigative tool is the biological profile, comprising estimates of sex, age, ancestry, stature, pathology and individualizing characteristics. The biological profile functions to reduce the number of missing persons who could be associated with the remains.

While validation studies of the methods used to estimate the biological profile saturate the forensic anthropology literature (see: Hartnett, 2010; Saunders et al., 1992; Murray and Murray, 1991; Martrille et al., 2007; Berg, 2008; Kimmerle et al., 2008; Fleischman, 2013; Hueze and Cardoso, 2008; Hens et al., 2008; Williams and Rogers, 2006; Rogers and Saunders, 1994; Rogers, 2005; Ramsthaler et al, 2007; Pritchard, 2007; Kemkes-Grottenhaler, 2005; Ubelaker and Volk, 2002; Ubelaker, 2009; Kosiba, 2000; Hughes et al., 2011; Urbanova et al., 2014; Guyomarc’h and Bruzer, 2011; Williams et al., 2005; Trotter and Gleser, 1958; Bedford et al., 1993; Klales and Kenyhercz, 2015; Kales et al., 2012), there are no studies that evaluate the application of the biological profile in casework. In essence, there is no external validation for the methods forensic anthropologists rely upon to conduct analyses. Further, validation studies conducted in academic research settings show disparities in the applicability of forensic methods.

Difficulties include, but are not limited to, the inability to effectively use the technique, the inability to apply the technique to various population groups, variability in the experience levels of the observers, ability to replicate results, and the level of bias entering into the analysis. Despite these variables, and the unknown error rates in
practice, anthropological methods are perceived to work sufficiently to justify their continued use (Sauer, 1992). A goal of this research is to discover if elements of the biological profile are prone to misclassification, and if they are, to identify which are most problematic, and what factors inherent to forensic casework contribute to these misclassifications.

To address the inherent disconnect between academic validation studies and the accuracy of the methods in forensic casework, this dissertation analyzes resolved skeletal cases from medical examiners' offices. Additionally, this study provides vital statistics of unresolved casework to document the demography of unidentified individuals represented in the medical examiners' offices, the physical condition of these remains, and any observable differences between resolved and unresolved casework. This research will provide the anthropological community with information regarding the accuracy of the biological profile of individuals in forensic casework and understand challenges associated with solving the large number of unresolved cases in U.S. medical examiners' offices. The ultimate purpose of this research is to allow forensic professionals to examine the efficacy of current techniques and guide the development of future forensic anthropological methods.

Following this introduction, chapters two and three provide a background to the main dissertation themes. The second chapter (1) discusses the medicolegal system providing missing persons statistics and chronicling difficulties associated with administering a search for the disappeared, (2) explores the rise of forensic anthropology and its inclusion into the medicolegal system, building an argument for the
importance of anthropological analyses to resolve unidentified human remains, (3) provides information about historic court cases that dictate the admissibility of forensic evidence and expert witness testimony. The constraints on forensic practice placed by the courts have profound implications for forensic anthropologists, as the scientific methods used rarely meet rigorous standards.

The final component of this chapter introduces forensic anthropology as a discipline, outlines the history of the field, examines the reference collections used to develop forensic anthropological methods, and describes the components of the biological profile and the commonly used methods to estimate the biological profile.

Chapter three discusses the challenges associated with providing law enforcement and death investigators a social race category from the estimation of biological ancestry. This chapter includes sections that (1) detail the history of racial classification, (2) describe the differences between race and ancestry including how the terms are used, (3) discuss the use of race and ancestry in forensic anthropology, and (4) address racial self-identification among the U.S. population.

Chapter four provides a description of the study sample locations. These offices were chosen for this research because each employs teams of anthropologists with large caseloads in populous and diverse cities.

Chapter five details the three research expectations posed to address the study aims.

Chapter six outlines the materials and methods used to test these research expectations and chapter seven presents the results.
Finally, chapter eight provides a thorough discussion of the findings and concluding thoughts.

In summary, this dissertation synthesizes several methodological processes that have garnered recent attention in anthropology and in the forensic sciences. These topics have an effect on the implementation and accuracy of forensic anthropology, but are not well understood outside the confines of experimental studies. Thus, the analysis of forensic cases within the context of this dissertation will document the accuracy of forensic anthropological casework within the framework provided by the academic and scientific communities as well as the framework provided by the medicolegal system specifically, the process of obtaining antemortem descriptions of missing persons.
CHAPTER TWO
BACKGROUND

Missing in the United States

Although this dissertation primarily focuses on the role of the anthropological report in the identification of unknown human skeletal remains, the purpose for discovering such information is to serve the population of the missing and their family members. Not all missing individuals become deceased or unidentified subjects of anthropological analysis and, in this review, we must not be reductionist about the resolution of missing persons cases, as countless factors influence such events. Rather, this dissertation focuses on the strategies used by forensic anthropologists to provide evidence for the identity of unidentified remains. Before addressing these strategies, this section identifies who goes missing, who remains missing, and a collection of factors that delay or hinder the investigation of missing persons.

Missing Persons Statistics

As of January 1, 2015 the United States FBI National Crime Information Center (NCIC) contained 84,924 active missing persons records. According to the NCIC, more than 2,000 individuals are reported missing in the United States each day. During 2014, there were 635,155 total entries in NCIC with most of those entries removed or cancelled due to the successful resolution of cases. However, these numbers do not
tell the entire story. Many more people are actually missing, as this total does not account for those Americans who have gone missing in other countries, POW/MIAs, or those never reported missing here at home. People go missing for a variety of reasons and, unfortunately, some die due to natural causes, accidents, suicide, or because they become victims of crime. In an ideal world, any deceased individual is identified and the remains returned to the family. In reality, not all remains are located and/or identified and not all remains are identifiable with current forensic techniques. The Bureau of Justice Statistics reports the extent of this situation finding that there are approximately 4,400 sets of unidentified human remains discovered each year with over 1,000 remaining unidentified after one year (Hickman et al., 2007). Currently, it is estimated that there are 40,000 sets of unidentified human remains housed in medical examiners offices around the country (Matthews, 2013; Ritter, 2007).

**Resources for Families**

The responsibility of locating missing persons primarily relies on family and friends as well as a conglomeration of local, county, and state law enforcement. In addition to local agencies, there are a number of national organizations that provide resources to identify missing persons and, when appropriate, identify the remains of deceased individuals. The National Center for Missing and Exploited Children (NCMEC) is an organization that provides services and resources for victims, families, and law enforcement in cases of missing children, child abduction, and sexual
exploitation. The International Committee of the Red Cross (ICRC) focuses on international efforts to locate missing persons and identify the deceased. Although they are primarily involved in locating missing persons outside of the US, they assist with locating missing Americans abroad. In addition, large-scale databases have been developed to facilitate information sharing to connect the dots of missing person's cases. Currently, there is no singular national integrated database to search for the missing or to identify unknowns in the United States; rather there exists a number of databases with varying levels of accessibility.

The National Missing and Unidentified Person System (NamUs) is a useful database that medicolegal professionals and the general public can access and search for missing persons. The database is comprised of information about missing persons cases and also unidentified deceased individuals. When an entry is made, the program automatically cross-references new information with records already contained within the database.

Similarly, the National Crime Information Center (NCIC), a function of the FBI, is a database that includes information about missing and wanted persons that can be readily searched. Unlike NamUs, which allows the free and open search of its records, only law enforcement officials can access the information contained within the NCIC.

The National Institute of Justice (NIJ) has funded several DNA identification projects to assist death investigations including a collaborative project with the University of North Texas Health Science Center. This program assists medical examiners and coroners with costs associated with DNA sampling, including
exhumations of unknown buried individuals to facilitate sampling, and the collection of family reference samples.

The listed organizations typically work in conjunction with death investigators, medical examiners and coroners, forensic anthropologists, forensic odontologists, non-profit and volunteer organizations, military personnel, and the Federal Bureau of Investigation (FBI) to resolve missing persons and unidentified cases. However, no comprehensive system exists to coordinate efforts across jurisdictions (Moore, 2011).

Demographics of the Missing

There are innumerable reasons why an individual may become a missing person. Some people disappear voluntarily, fed up with their lives wishing to start anew. Some people are victims of crime and disappear at the hands of another. Some people are victims of their own circumstances; where becoming one of the missing is a byproduct of their actions or inability to make decisions in their own best interest (Moore, 2011).

Despite the circumstances for disappearance, many people, when discovered missing, are reported to police by a concerned party, such as a family member, friend, co-worker, or other acquaintance. However, actions taken by law enforcement when a report is filed vary among departments.

Carole Moore is a former police officer and trained investigator with an interest in missing person’s cases. Her book, The Last Place You’d Look (2011), chronicles the barriers faced by family members and police officers in the resolution of missing
person’s cases. Real stories of missing persons provide narratives that illustrate the obstacles encountered from the beginning to the end of an investigation. She notes that there is no particular protocol in place to deal with missing person’s cases when they arise and not all cases are given the same level of attention. In fact, very few police departments have officers trained in missing person’s cases, let alone entire missing persons units. Those that do are concentrated in large cities, but their reach is limited by their jurisdiction. Deficiencies in training, jurisdictional constraints, and a lack of communication between police departments, are among the main obstacles facing investigations of missing persons cases. How cases are handled varies dramatically from state to state and even from precinct to precinct; resources, (monetary and personnel) are disparate (Moore, 2011). For example, police do not hesitate to take a report when a young child is reported missing, however, adults, and even very young adults barely at the age of majority, are treated very differently (Moore, 2011).

Children

Missing children are often given the full attention of law enforcement because they are considered vulnerable and unable to access employment or resources (Kiepal et al., 2012). As such, police reports are typically taken in a timely manner, AMBER Alerts are issued in the case of alleged abductions, media outlets are notified, and large-scale search operations are deployed. However, not all children are given this kind of attention. In fact, many states consider teenagers to be adults at the age of sixteen and law enforcement will not look for them unless foul play is suspected in their
disappearance (Moore, 2011). Furthermore, if a child deemed old enough to be on their own is found, officers do not have the legal authority to inform the parents of their whereabouts (Moore, 2011).

Moore spends a considerable amount of time in her book discussing runaways, who are of particular concern because they are more likely to be exposed to harm and more likely to experience personal victimization, sexual exploitation, and drug and alcohol abuse (Moore, 2011; James et al., 2008; Gaetz, 2004, Payne, 1995). She cites that many police departments lack the resources necessary to find runaway children. Children making the decision to leave home do so for a variety of reasons, but are usually subjected to unfortunate circumstances in the home such as violence, parental substance abuse, or other conflicts, that compel them to leave (James et al., 2008; Dalley, 2007; Gaetz, 2004; Dedel, 2006). Some children have mental conditions including, but not limited to, attention deficit disorder and bipolar disorder. These young people are typically impulsive and can make the decision to leave home when angry with their parents or face some situation they cannot control (Moore, 2011). More often than not, runaways occur as a result of troubled and broken homes, sexual abuse, parental substance use, child substance use, problems in school, and violence (James et al., 2008; Gaetz, 2004; Moore, 2011). In some cases, being found is not a desired outcome for the missing child (Payne, 1995).
Adults

Unlike children, adults are considered to have the right to disappear if they want to. Unless a disappearance occurs under suspicious circumstances, police often do not take a report of a missing adult or young adult, citing shoestring budgets and lack of personnel to conduct investigations (Moore, 2011). Some police departments fall back on the old forty-eight hour rule, which dictates that a report is taken only after a person has been missing for at least 48 hours, denying the family a formal report prior to that time. Although law enforcement generally acknowledges that waiting to file a report is detrimental to an investigation, many agencies still resist taking a report on a missing adult (Moore, 2001). The widespread misperception that adults go missing voluntarily not only hinders the investigation, but also continues to dampen efforts to understand what factors underlie adult disappearances (Biehal et al., 2003).

Marginalized Populations

Not everyone is afforded the financial and social resources required to live a socially acceptable standard of living (Room, 1995; Percy-Smith, 2000; Burchardt et al., 1999; Byrne, 2005; Peace, 2001 Sen, 2000). Marginalized members of society are individuals who, for whatever reason, live on the fringe of society. These individuals include the homeless, prostitutes, the elderly, minority groups, the mentally ill, children with a history of running away, illegal immigrants, and others living without strong ties to society (Moore, 2011; Keipal et al., 2012; Patterson, 2005).
In general, socially excluded individuals are more likely to go missing and are less likely to be found (Kiepal et a., 2012). For example, underprivileged women, especially those who experience domestic abuse, are more likely to go missing than women who have access to resources (Patterson, 2005; James et al., 2008). This situation is exasperated when these underprivileged women are members of a minority group (Kiepal et al., 2012).

Another example is the homeless. Homeless individuals go missing in high numbers because they lack relationships with family members, are typically unemployed, and experience other avenues of social exclusion (Gaetz, 2004; Keipal et al., 2012). According to the National Student Campaign for Hunger and Homelessness, there are approximately 3.5 million homeless people in the United States; 35% are families with children, 23% are U.S. military veterans, 5% are children under 18 years of age, 30% have experienced domestic violence, and 20-25% suffer from mental illness (retrieved March 6, 2015).

To locate a missing person, law enforcement requires notification, a physical description of the missing, last known whereabouts, and any other information useful to an investigation. Law enforcement depends on a willing third party for this information (Payne, 1995). Therefore, persons lacking connections with society or those without concerned family members or friends will not be reported (Payne, 1995; Kiepal et al., 2012). Also, social or familial networks associated with missing marginalized individuals are similarly marginalized and thus, may be reluctant to approach law enforcement with information (Kiepal et al., 2012). Illegal immigrants and individuals with criminal records
wanted by law enforcement are less likely to report a missing person for fear of legal action being taken against them. Similarly, if a missing person is in the country illegally, a concerned third party may not report their disappearance for fear that legal action may be taken against the surviving family members (Anderson, 2008).

Missing marginalized individuals often do not have recent medical or dental records on file and may not have family members to provide antemortem information or DNA samples for comparison (Anderson, 2008). As a result, marginalized individuals are more challenging to identify and may represent a significant portion of the nation's unidentified human remains (Moore, 2001; Keipal et al., 2012). In addition, missing marginalized individuals often are not afforded the full attention and resources of law enforcement (Moore, 2011).

In contrast, prominent individuals such as young white women and children are typically reported missing in a timely manner (Barton, 2011; Moore, 2011). This is because the general population takes an interest in these cases. Barton (2011) explains that the media perpetuates the “missing white woman syndrome,” where missing young white women (e.g. Lacey Peterson and Natalie Holloway) are given the full attention of the media, bolstering considerable interest among viewers, increasing viewership and ratings. Moore (2011) highlights the 2007 case of Adam Kellner, a middle-aged schizophrenic man who went missing from the home he shares with his family. His mother, Sherrill Britton, states that mentally ill individuals are less valued and there is prejudice against the mentally ill. “If he were a beautiful blond or a five-year
old, his case would get tons of publicity. A thirty-five-year-old mentally ill man is not a sexy case; it just isn’t” (p.103).

It is a sad and desperate situation when someone goes missing in the United States. Families, friends, and concerned parties expect law enforcement to provide answers and deploy all available resources to resolve cases. However, police departments face financial constraints, manpower issues, and communication failures that hinder efforts to locate the missing. Unfortunately, socially excluded individuals who lack meaningful relationships and access to resources are the ones at risk of remaining unidentified. Forensic anthropology has become a part of the medicolegal system in an effort to identify unknown deceased individuals. The next section outlines the responsibilities of the anthropologist in the medicolegal system.

Forensic Anthropology in the Medicolegal System

Forensic anthropologists occupy a relatively new and unique division within biological anthropology. This section provides a brief history of forensic anthropology detailing the events that led it to be a prominent discipline that is touted through world-renowned university departments, and popular crime TV shows and documentaries alike. But, it is first necessary to describe the function of the medicolegal system in order to understand why anthropologists are necessary and valuable contributors.
The Medicolegal System

According to the American Heritage Dictionary (2011) the medicolegal system is defined, “of, related to, or concerned with both medicine and law, as when medical testing or examination is undertaken for a legal purpose.” Simply stated, this definition describes the application of medical sciences for the purpose of legal investigations. In the United States, the medicolegal system consists of a network of law enforcement, physicians, medical examiners/pathologists, coroners, forensic scientists, death investigators, lawyers, and courts. Forensic anthropology’s rapid and recent development has encouraged broad applications of the science directly into the medicolegal system. Before we explore the history and evolution of forensic anthropology, the following section defines the contributions of forensic anthropology within the medicolegal system.

Forensic anthropology is the “application of anthropological and skeletal biological principals to medicolegal issues” (Steadman, 2009; p.1). Due to their unique osteological training, forensic anthropologists are essential to the medicolegal system as they frequently assist law enforcement with the many aspects involved with the identification process of deceased individuals. However, duties of a forensic anthropologist are not limited to skeletal analysis. Responsibilities are diverse and include the search and recovery of human remains, maceration of soft tissue from bones, analysis of the biological profile, the evaluation of skeletal health, pathology, and trauma events, and the assessment of the postmortem interval and other taphonomic processes (Byers, 2005). To assist with identifications, anthropologists document ante-
and peri-mortem skeletal trauma, skeletal pathologies and anomalies, surgical implants and other individualizing characteristics.

To develop a biological profile, forensic anthropologists rely on population level morphological characteristics of skeletal remains to compare with missing person descriptions. The biological profile typically consists of an individual’s sex, ancestry, age, and stature, and is used to help narrow the field of potential matches. Additionally, forensic anthropologists compile a detailed report of their findings and, if necessary, present those findings in court.

A Brief History of Forensic Anthropology

One of the earliest accounts of anthropological methods utilized comes in the late 1800s by way of a scientist, forensic investigator, photographer, and forerunner of fingerprint analysis named Alphonse Bertillon (Rhodes, 1956). Bertillon spent a good portion of his career developing standards to analyze fingerprints at crime scenes and collect anthropomorphic data. Using this expertise, Bertillon was asked to assist with victim identification following the 1896 Drummond Castle tragedy. The Drummond Castle was a large ship carrying 252 passengers and crewmembers that sank in the Fromveur Sound off Ushant, a French island at the southwestern end of the English Channel. Over the course of several days, a total of 53 bodies were recovered with 27 receiving “official descriptions” that included photographs and physical descriptions of the deceased and their personal effects. Physical descriptions were detailed and
crafted with an attempt to reconstruct what the person looked like in life. The descriptions were provided by Bertillon in his official reports and resulted in 10 positive identifications.

Although victim identification did not directly lead to the development of forensic anthropology, it is noted that the process of identifying the dead has undergone gradual changes as scientific discoveries are made. The process of putting a face, and ultimately a name to the deceased is rich in history while its transition to identifying a face and name from skeletal materials is fairly recent.

Forensic anthropology, as it is known today, underwent a rapid evolution within the discipline of physical anthropology. This new sub-discipline was born from the combination of physical anthropology and specialized training and analyses of human anatomical structures. Knowledge of human anatomy was seen as a valuable tool for early police investigators as they discovered it could be used to help identify and interpret evidence to solve crimes.

It is said that Thomas Dwight (1843-1911) was the first to make a career from the analysis of skeletal remains and that his writings were the first of their kind to apply the analysis of the human skeleton to forensic cases. His work and life-long commitment to researching forensic applications of the skeletal form and participation in forensic cases gained him the title, Father of Forensic Anthropology in the United States (Stewart, 1979). Although the roots of employing anatomical expertise to help identify victims of crime in the United States has extended back to the mid-1800s, the so-called modern era of forensic anthropology can be marked with W.M. Krogman’s landmark publication,
Guide to the Identification of Human Skeletal Material, in 1939. The guide served as the authoritative work in forensic anthropology and was utilized by the larger anthropological community and the FBI (Stewart, 1979). During this time, many notable anthropologists, H.L Shapiro, Charles E. Snow, Mildred Trotter, and T. Dale Stewart were involved in the identification of war dead and had used Krogman’s research to assist with their operations (Ubelaker, 2009). The extensive use of Krogman’s work led to advancements in methods and techniques such as Trotter and Gleser’s stature estimation methods (1952) and McKern and Stewart’s age estimations (1957). When Ales Hrdlicka retired from the Smithsonian Institution in 1942, his successor, T. Dale Stewart, immediately began working on FBI cases. By 1969, he had worked 254 cases with 169 being at the request of the FBI (Ubelaker, 2009). His casework experience allowed him to recognize the need to improve forensic methods and techniques, and as such, published, Skeletal Changes in Young American Males in 1957, with his colleague, Thomas McKern. Several more publications followed and a culmination of forensic research was presented in his 1979 textbook, Essentials of Forensic Anthropology.

Advancements in forensic science during this historic period were not just limited to the achievements of individuals. In 1950, the American Academy of Forensic Sciences (AAFS) was founded (Eckert, 1980) as a multi-disciplinary professional organization to provide leadership and advance science with its application to the legal system (Reichs, 1988). The objectives of the academy are to promote professionalism, integrity, competency, and education, foster research, improve practice, and encourage
collaboration in the forensic sciences. It wasn’t until 1972 that the Physical Anthropology section was created, a development that marked a new beginning for forensic anthropology (Kerley, 1978). The field’s certifying board, the American Board of Forensic Anthropology (ABFA), was founded in 1977 (Reichs, 1988) and was essential to the development of scientific credibility with the initial certification of 22 diplomats. Today, the Physical Anthropology section has been renamed “Anthropology” to include the foundation of the discipline.

**Forensic Anthropology Today**

Today, forensic anthropology is a highly competitive field encompassing high standards for education, research, and professional applications. Notably, the past 15 years have seen an increased interest in forensic anthropology (Hart, 2009); likely a result of popular media, books, and TV shows (Ubelaker, 2009) highlighting the glamorous work of anthropologists solving difficult cases (e.g., “Bones” and “CSI”). The effects of the excitement around this growing field are evidenced by an increased demand for education and specialized instruction in anthropology departments within universities all over the world (Black, 2013). Many colleges and universities now offer undergraduate and graduate level coursework in forensic disciplines as well as a variety of training certification programs. Workshops, short courses, and internship opportunities are offered up as additional training and specialization for individuals interested in pursuing a career in forensic anthropology (see: University of Tennessee
Forensic Anthropology Center, Mercyhurst University, Southern Institute of Forensic Sciences). In addition to academic positions, aspiring forensic anthropologists can seek out employment positions in the private sector including, but not limited to, death investigation, autopsy technicians, photography, and compliance officers (Hart, 2009).

Research and technology have also greatly benefited from the recent rise of forensic anthropology. There is an ever-increasing need to discover the next new breakthrough method that will help identify the unknown. It is true that significant research advancements have been made, not only through the efforts of an increased number of researchers, but also through the expansion of study databases, skeletal collections, sophisticated statistics, and computer software (Ubelaker, 2009). Research topics have expanded well beyond efforts to study the biological profile and include issues related to trauma analysis, individualization, the postmortem interval, child abuse, observational bias, validity of techniques, evidentiary standards, comingling, disaster victim identification (both here and abroad), and more.

**Employment in Medical Examiners’ Offices**

By 1980, physical anthropologists were slowly being considered for employment in medical examiner’s offices. However, the demand for anthropological casework was irregular and therefore, full-time employment was difficult to justify (Berryman, 2009). The first full-time forensic anthropologist in the United States was Dr. Hugh E. Berryman at the Shelby County Medical Examiner’s Morgue in Memphis, Tennessee. The
position as Morgue Director provided administrative duties that supplemented his anthropological responsibilities and thus justification for the full-time position (Berryman, 2009). In 1981 the New Jersey State Police hired Donna Fontana as a forensic anthropologist and forensic microscopist. Amy Zelson Mundorff was the first forensic anthropologist at the Office of Chief Medical Examiner (OCME) in New York City. During her tenure (1999-2004), she assisted with a number of local cases and demonstrated the value of having a forensic anthropologist readily available to help recover and analyze skeletal materials. In her employment, she conducted the largest triage operation in the history of the United States demonstrating the unique and specialized skills anthropologists utilize to handle large-scale disasters.

The attacks on the World Trade Center in 2001 left in its wake 2,996 deceased individuals and Dr. Mundorff helped lead the operation to identify thousands of sets of human remains. The effort to identify every victim from that tragic event continues today with the expertise of forensic professionals in many fields, including forensic anthropologists (Checker et al., 2011).

Today, the number of anthropologists employed in medical examiner’s offices has grown markedly (Mundorff, 2011) and many more anthropologists provide consultations for medical examiner’s offices, coroners, local law enforcement, and FBI. The offices researched for this study include Office of Chief Medical Examiner in New York City, New York; the Harris County Institute of Forensic Science in Houston, Texas; and the Pima County Office of the Medical Examiner in Tucson, Arizona. These offices utilize full-time anthropologists, postdoctoral students, interns, and volunteers.
While it is true that the dramatization of forensic anthropology in the media and popular television shows has drawn substantial attention to the profession, it is the tireless work of many physical anthropologists over the years that define the discipline today. Direct participation in missing persons cases and the expertise utilized in disaster victim recovery and identification has proven that anthropologists are key players in the medicolegal community. The continued partnership and cooperation between forensic professionals and law enforcement officers is invaluable for the successful resolution of missing persons cases. To do so, forensic anthropologists are required to meet the standards of evidence prescribed by the courts. The following section describes the evolution of the standards of evidence and expert witness testimony in the United States and how forensic anthropology works to meet those requirements.

**Evidentiary Standards for Forensic Anthropology and Historic Court Decisions**

This section addresses the standards of forensic evidence and expert witness testimony in the United States court system over the past 22 years. Several landmark federal court decisions have determined the criterion and have deemed judges the gatekeepers for the admissibility of credible scientific evidence. This allows judges to “evaluate expert witness testimony on a case-by-case basis” (Grivas and Komar, 2008:771). Although forensic anthropology was not specifically cited in the NAS report,
these significant court decisions have impacted the rigor of scientific applications and methods for all disciplines under the realm of forensic science.

_Frye v. United States (1923) and the Federal Rules of Evidence (1975)_

In 1923, the District of Columbia Court of Appeals made the first decision by a federal court to standardize the admissibility of forensic evidence for testimony. This ruling was considered to be one of many “common law rules,” (Grivas and Komar, 2008:771) the United States judicial system followed regarding the admissibility of expert witness testimony in all cases, but predominantly in criminal cases (Bernstein, 2001). The rule stated that scientific evidence, “must have gained general acceptance in the particular field in which it belongs” (Frye, 1923) and as such, testimony was considered reliable if the “methods and procedures of science” (Frye, 1923) were applied. The purpose of this ruling was to determine the relevance and reliability of scientific evidence and the methodologies used to glean the results presented in court. However, the _Frye_ test was fundamentally ambiguous, allowing variation in its interpretation between jurisdictions and judges (Lyons, 1997) and was formally cited in only a few dozen published cases in the 1960’s (Bernstein, 2001). The ambiguity of the _Frye_ test as well as the unknown influence the _Frye_ ruling had on court cases went largely ignored until 1975 when the Federal Rules of Evidence (FRE) were established for federal courts (Bernstein, 2001).
The Federal Rules of Evidence were created and subsequently adopted by Congress to address the ambiguity and variability in the applications that the Frye test presented in federal courts. The purpose of the Federal Rules of Evidence was to “formally standardize and clarify the trial process in the federal judicial system” (Grivas and Komar, 2008:772). Specifically, Rule 702 determined who qualified as an expert witness and when witness testimony was appropriate. It did not, however, address the application of the Frye test, which, as previously described, dealt with the admissibility of scientific evidence.

In 1993 the Supreme Court made a landmark decision in the case of Daubert v. Merrill Dow Pharmaceuticals, Inc. (1993). This ruling ultimately clarified the confusion of the Frye test and the Federal Rules of Evidence in federal courts. Many states still use the Frye rule today.

*Daubert v. Merrill Dow Pharmaceuticals, Inc. (1993)*

The *Daubert v. Merrill Dow Pharmaceuticals, Inc. (1993)* decision required scientific evidence to attain reliability and relevance standards and was intended to clarify the unclear principles of the Frye ruling and FRE 702 (Holobinko, 2012). Ultimately, *Daubert* determined that the Federal Rules of Evidence superseded the *Frye* rule in federal cases (Holobinko, 2012). In addition, the court concluded that individual judges, not the scientific community, have the authority to determine the reliability and admissibility of scientific evidence and expert witness testimony. Since judges are not
scientific experts, Daubert established five guidelines for which judges could follow to evaluate scientific witness testimony. These guidelines mandate that the content of witness testimony must: (1) be testable and have been tested through the scientific method, (2) have been subject to peer review, (3) have established standards, (4) have a known or potential error rate, and (5) have widespread acceptance by the relevant scientific community (Daubert, 1993). In essence, the Daubert ruling allows judges to be the gatekeepers of expert witness testimony while keeping junk science out of the courtroom (Faigman et al., 1997). Although well intentioned, these guidelines, as Grivas and Komar (2008) state, “put clear and significant constraints on the admissibility of scientific expert witness testimony” (p.772). However, it is important to note that the Daubert ruling applies to federal courts observing the Federal Rules of Evidence. Some states adhere to Frye while other states have adopted standards similar to Daubert.

Since the Daubert ruling, two Supreme Court cases have refined the Daubert standards for expert witness testimony, General Electric v. Joiner (1997) and Kumho Tire Co. v. Carmichael (1999). Collectively, these cases are known as the Daubert trilogy.


In a Supreme Court ruling, General Electric v. Joiner (1997) established that the expert witness needed to justify his or her opinions by explaining how the scientific methodology relates to the evidence in the case, and thus, how the conclusions were
made. In this case, the expert witness testimony failed to demonstrate a link between polychlorinated biphenyl (PCB) exposure and small-cell lung cancer that the plaintiff claimed to have developed as a result of working around PCBs on the job. This ruling focused attention back to the final conclusions determined, rather than the strict rules for scientific evidence (Christensen and Crowder, 2009). According to the court, there is nothing in the Federal Rules of Evidence or in Daubert that requires the court to accept unproven assertions of the expert witness (Joiner, 1997). The court’s decision found that an expert’s conclusion should not be admissible if valid reasoning does not support the methodology and conclusions. However, it was still unclear if the Daubert standards and the judge’s gatekeeping responsibilities applied only to scientific testimony or also to technical testimony. Scientific testimony refers to testimony that is given by scientists and supported by the five guidelines set forth in the Daubert criteria, whereas technical testimony is testimony given by experts in a given field that are not scientists but the testimony is based on scientific principles. These questions would be addressed in the 1999 Supreme Court ruling in Kumho Tire Company, Ltd v. Carmichael.

**Kumho Tire Company, Ltd v. Carmichael (1999)**

In *Kumho Tire Company, Ltd v. Carmichael*, the trial judge ruled that the expert witness testimony in the case of an accident potentially caused by a failed tire did not satisfy the requirements set by the Daubert ruling and thus, was not admissible. The
appellate court, however, ruled that because the expert witness was not a scientist, the non-scientific testimony given was not subjected to the *Daubert* criteria. Ultimately, the Supreme Court ruled that expert witnesses, even if they are not scientists, could develop and apply theories for the court based on their observations and experiences so long as these theories are reliable and relevant to the case at hand (*Kumho*, 1999). The judge, being the gatekeeper of expert witness testimony, now does not have to differentiate between scientific testimony and technical testimony, as all expert witnesses can now be evaluated at the same level. This ruling also suggested that the strict *Daubert* standards do not always apply; instead, they were actually designed to be a “set of flexible guidelines rather than a strict set of rules” (Grivas and Komar 2008:772) for evaluating the validity of expert witness testimony. Furthermore, the flexibility of the guidelines recognizes that scientific advancements often outpace publication and general acceptance within any given field and that testimony utilizing emerging scientific techniques can still be considered valid. Thus, *Kumho* does not supersede *Daubert*; rather it provides flexibility to evaluate the merit, and therefore the admissibility, of forensic evidence and expert witness testimony.

**Implications for Forensic Anthropology**

The preceding court rulings have profound implications for the admissibility of scientific evidence and the standards for expert witness testimony. More specifically,
these rules affect the development of scientifically admissible methods within anthropology.

In their 2009 article titled, “Evidentiary Standards for Forensic Anthropology”, Christensen and Crowder explicitly acknowledge that forensic anthropology is a problematic discipline in regards to evidentiary standards. The authors outline concerns regarding the credibility of forensic anthropological methods and how they fail to meet rigorous standards for evidence outlined by the Daubert ruling. Christensen and Crowder (2009) explain that the techniques used today are a combination of results gleaned from rigorous scientific methods and also less rigorous observational methodologies, examples from casework, and personal experience. According to Daubert, anecdotal examples from casework, personal experience, and non-scientific observational patterns are not deemed appropriate for evidence in court. In addition to the problems associated with the standards of evidence, the forensic anthropology community has no single standard for which to conduct the recovery and analysis of human skeletal materials. This implies that each anthropologist or institution is permitted to employ his or her own guidelines and standards for forensic practice (Christensen and Crowder, 2009). Regardless, Grivas and Komar (2008) state that many anthropological methods meet the Kumho criteria. Christensen and Crowder (2009) point out that Kumho is not a stand-alone criterion because the ruling allows for flexibility in the application of the Daubert guidelines. Nevertheless, most forensic anthropological methods do not meet Daubert guidelines for admissibility and may be deemed too subjective (Christensen and Crowder, 2009).
In 1977, the American Board of Forensic Anthropology (ABFA) was formed to provide certification of the expertise for individuals who practice forensic anthropology. Despite the success and growth of the organization, there are still no protocols in place to "ensure the consistency and reliability in the application of forensic anthropological methods" among its members (Christensen and Crowder, 2009:1211). Moreover, the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB) can and has accredited forensic anthropology laboratories, but they do not recognize anthropology as an independently certifiable field.

In 2009, the National Academy of Science (NAS) published a document titled, “Strengthening Forensic Science in the United States: A Path Forward.” This report was the result of the formation of a special forensic science task force ordered by the United States Congress to identify the needs and shortcomings of various forensic disciplines. The comprehensive analysis of “the state of forensic science” in the United States was followed by a set of recommendations for future forensic practice. One such recommendation asks that the forensic community, “disseminate the best practices and guidelines concerning the collection and analysis of forensic evidence to help ensure quality and consistency in the use of forensic technologies to solve crimes, investigate deaths, and protect the public” (NAS Report, 2009:2).

In response to the suggestions put forth by the NAS report, the American Academy of Forensic Science (AAFS) encouraged the development of Scientific Working Groups (SWG), to establish best practices for each sub discipline. The physical anthropology section of AAFS along with the Federal Bureau of Investigation,
and the Department of Defense Central Identification Laboratory formed the Scientific Working Group of Anthropologists (SWGANTH) to develop guidelines for best practice in forensic anthropology. These guidelines recommend that forensic anthropologists use methods accepted by the anthropological community and to be cognizant of reference samples, statistics, and population demographics when employing each method. Further, SWGANTH recommends that anthropologists be conservative in their assessments so not to unintentionally exclude individuals from a presumptive identification.

Although the guidelines outlined by SWGANTH are appropriate, they do nothing to ensure the consistency or precision of scientific practice in forensic anthropology. And while the NAS report doesn’t specifically target the biological profile as being problematic, it makes the point that forensic methods need to provide error statistics (e.g. confidence intervals). These error statistics help to evaluate the accuracy or precision of methods. The overall lack of regulation and scarcity of measurement error in forensic anthropological practice leads to inconstant applications of forensic methods, a reduction in evidentiary value, and may result in the possibility that deceased missing persons remain unidentified.

Although many recent anthropological publications emphasize the importance of meeting Daubert criteria (Christensen, 2004; Christensen 2005; Rogers and Allard, 2004; Rogers, 2005), anthropological methods reliant on subjective analysis, largely do not meet the rigorous standards required by the rulings. Judges, being gatekeepers of evidentiary testimony, decide before hearings whether the expert will testify and if the
evidence is admissible. This is not a problem when we remember that the *Kumho* decision allows for more lenient interpretation for the standards of evidence and testimony. However, savvy lawyers will argue the credibility of evidence according to the *Daubert* standards. Further, the CSI effect has had profound affects on how juries view evidence (Dauria and Quintyn, 2007). The CSI effect is a phenomenon where popularized television shows such as *CSI* and *Bones* generate unrealistic expectations for the accuracy and expediency of forensic techniques (Dauria and Quintyn, 2007). Yet despite the *Kumho* ruling, Steadman et al. (2006) state, “A judge may disallow expert testimony if the report is poorly written, the scientific method is unsound, error rates are not included, or the report otherwise does not demonstrate a minimum threshold of reliability and relevance” (p.16). Reliability and relevance here means that the methods employed and the conclusions drawn by the expert witness from the evidence pertain to the case at hand. Steadman et al. (2006) add that when the identity of an individual is at issue, the forensic anthropologist must (1) define technical terms, (2) document any problems when applying methods, (3) include error rates, and (4) include a summary statistic, such as a likelihood ratio, that reveals the strength of the presumed identification.

**Presumptive vs. Positive Identification**

The identity of deceased individuals may not be known at death or at the time of discovery, but is of utmost importance to the investigation of death (Wiersema et al.,
2009). Some individuals are discovered with identifying information such as a driver’s license that can indicate the possible identity of the decedent; additionally friends and family members can verify the identity of fresh or intact bodies (Holobinko, 2012). However, individuals that are skeletonized, decomposed, dismembered, or lack identifying media pose a challenge for death investigators when establishing identification. There are two types of identifications, positive and presumptive and depending on the circumstances of death, a positive identification may be required.

A positive identification is reached when evidence is found to connect the identity of human remains to the identity of a missing person through the use of scientific processes (Holobinko, 2012; Komar and Buikstra, 2008; Rogers and Allard). According to the 2010 SWGANTH document titled “Personal Identification,” positive identifications can be made when “antemortem and postmortem information match in sufficient detail to conclude that they are from the same individual to the exclusion of all other reasonable possibilities” (p.2). In other words, a positive identification can be made based on a unique or individualizing characteristic. Accepted methods for positive identification of deceased individuals include fingerprints, nuclear DNA, and medical and dental records (Holobinko, 2012). For unidentified skeletal remains, positive identification is usually achieved through a DNA match, anthropological comparison of antemortem and postmortem medical or dental radiographs (Mundorff et al., 2006, Christensen 2005), or the identification of a surgical device (Wilson et al., 2011; SWGANTH, 2010).
A presumptive identification is established when scientific modalities are not obtainable and instead the identification relies on contextual and circumstantial evidence (Wiersema et al., 2009). Anthropologists can typically provide information that can lead investigators to a presumptive identification through the construction of the biological profile, but cannot provide positive identification in the absence of antemortem medical and/or dental radiographs. Oftentimes, the anthropologist is helpful in excluding a potential identification based on the mismatch of antemortem and postmortem radiographs, bones, and comparisons to the antemortem reports.

In cases going to trial, however, a presumptive identification may be insufficient and methods for positive identification are subject to the Daubert criteria (Wiersema et al., 2009). In the absence of fingerprints or DNA, comparisons of antemortem and postmortem radiographs can be used to establish a positive identification. Christensen (2004) and Wiersema (2006) have published methods for positive identification utilizing the frontal sinuses and petrous portion of the temporal, respectively. These methods satisfy the Daubert criteria not only providing the probability of an individual match, but also the likelihood estimate - the probability of the correct identification among the general population (Christensen, 2004; Wiersema, 2006; Steadman, 2006).

Without strict standards for evidence and expert witness testimony, many forensic practitioners could willingly or unwillingly falsify evidence. Forensic anthropologists acting as expert witnesses and the methods used are not immune from scrutiny based on the standards set forth by the courts. The heightened evaluations of anthropological methods serve to improve their accuracy and precision, and make
forensic anthropologists better scientists, statisticians, and expert witnesses. This is a change forensic anthropologists should welcome, as poor science has no place in the courtroom when the identity of a person and circumstances surrounding their death, as well the fate of the accused, is on the line.

The Biological Profile

As noted, the anthropologist is responsible to construct a biological profile from skeletal remains to assist with identification. This section reviews four elements of the biological profile: sex, age, ancestry, and stature and the reference collections commonly used to develop forensic anthropological methods. The review will also focus on the complications associated with assessing these components biological profile including the benefits and drawbacks of using different anthropological methods. Emphasis will be placed on adult estimation techniques, as they represent the majority of cases examined for this study.

Reference Collections

Anthropological methods used to establish the biological profile were developed from skeletal reference collections. Due to the court decisions previously discussed, many forensic anthropological procedures are now under scrutiny, stemming from a myriad of issues including that many methods lack statistical robusticity and rely on
subjective observations dependent on the skill level of the observer. The improvement of evidentiary value in forensic anthropology lies in the proper execution of methods as well as the proper materials from which to extrapolate information. Data-based methods with the ability to separate individuals with an acceptable degree of accuracy (as deemed by the courts) is a desired outcome of the NAS report. However, skeletal reference collections where much of the data is gathered are limited in scope and have reduced power when they do not reflect the population upon which the method or technique is used (Komar and Grivas, 2008).

In the 1930s during the early developmental years of forensic anthropology, researchers led by Wilton Marion Krogman focused on studies of skeletal growth, nutrition, descriptive techniques, and paleodemography (Iscan, 1988). Examinations were dedicated to age estimation in subadults, and sex and race assessment in adults. Many of the investigations were conducted on two skeletal collections available at the time: the Terry Collection at the Smithsonian Institution and the Hammon-Todd Collection at the Cleveland Museum of Natural History (Iscan, 1988). These valuable skeletal collections were compiled during the first half of the 20th century and include 19th century individuals of known sex, age (approximated in Hammon-Todd), race, height, and cause of death. Up until this point, these collections represented the most comprehensive information available for skeletal analysis.

Over time, a number of skeletal reference collections have amassed including historic cemetery collections, anatomical collections from medical examiners’ offices, and donated collections of modern-day Americans. The expansion of available skeletal
materials has allowed anthropologists to create new methods and perform validation studies of existing methods from other collections. Although collections and access to them have increased over the years, they are not reflective of the general population (Komar and Grivas, 2008). Further, new methods developed from these collections are strongly influenced by the original methods and are limited in their application to the overall population.

In order to evaluate the validity of forensic analyses, it is important to understand the impact these collections have on forensic practice, even today. The way in which early research was conducted with these collections permeates the development of research questions and creation of modern techniques. In other words, preliminary studies utilizing these collections have set the precedence for, and have influenced how anthropologists conduct studies and frame contemporary research questions.

**Influential Skeletal Collections**

Table 1 is an abridged table taken from White et al. (2012) that outlines the most utilized skeletal collections in forensic anthropological analysis. This table is updated to reflect current populations of these collections. A more detailed discussion of the six most influential collections (Terry Anatomical Collection, Hammon-Todd Collection, McKern and Stewart Collection, LA County Coroner’s Office Collection, Maxwell Museum Documented Skeletal Collection, and the William M. Bass Donated Skeletal Collection) follows. Note the Maxwell Museum Documented Skeletal Collection and the
William M. Bass Donated skeletal collections continue to receive donations and their demographics reflected in the table constantly change.

Table 1 shows the most utilized skeletal collections for the development of forensic anthropological methods. The information clearly illustrates that the collections are primarily comprised of black and white individuals and the majority of the individuals are male. The significance of such limited demographic representation in these collections cannot be ignored (Komar and Grivas, 2008). The methods developed from the above collections are limited in their applicability to underrepresented populations; populations that, as indicated in previous sections, are marginalized and may be represented in larger numbers in the medicolegal system.

**Terry Anatomical Collection**

The Robert J. Terry Anatomical Collection, also known simply as the Terry Collection, is currently housed at the Smithsonian Institution Museum of Natural History in Washington D.C. Dr. Terry was an anatomy professor and head of the Anatomy Department at Washington University Medical School in St. Louis, Missouri from 1899-1941. He was interested in pathological conditions of the human skeleton, but efforts to improve his research were hindered by a lack of reference and research materials. In the 1920s, he began to collect skeletal materials from cadavers donated to the university’s medical school. The bodies were primarily sourced from a local hospital, but other institutions in Missouri also made contributions. In all, there are 1,728 individuals of known sex, age, ancestry, cause of death, and pathological conditions
Table 1. Documented Skeletal Collections – Modified from White et al. (2012)

<table>
<thead>
<tr>
<th>Collection</th>
<th>Individuals</th>
<th>Dates of Death</th>
<th>Sex Bias</th>
<th>Age Bias</th>
<th>Ancestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamann-Todd</td>
<td>3,713</td>
<td>1912-1938</td>
<td>80% male</td>
<td>Most 20-80</td>
<td>61% white 38% black</td>
</tr>
<tr>
<td>Korean War Dead</td>
<td>450</td>
<td>1950-1953</td>
<td>Primarily male</td>
<td>Most 17-25</td>
<td>Primarily white</td>
</tr>
<tr>
<td>Terry</td>
<td>1,728</td>
<td>1920-1965</td>
<td>59% male</td>
<td>Most &gt; 45</td>
<td>45% white 54% black</td>
</tr>
<tr>
<td>Huntingon</td>
<td>4,054</td>
<td>1892-1920</td>
<td>75% male</td>
<td></td>
<td>70% white</td>
</tr>
<tr>
<td>LA County Coroner</td>
<td>1,225</td>
<td>1977-1979</td>
<td>60% male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W. Montague Cobb</td>
<td>634</td>
<td>1932-1969</td>
<td>70/5 Male</td>
<td>Most &gt; 25</td>
<td>84% black 19% white</td>
</tr>
<tr>
<td>NMNH Fetal</td>
<td>320</td>
<td>1904-1917</td>
<td>54% male</td>
<td>Fetal neonate</td>
<td>43% white 54% black</td>
</tr>
<tr>
<td>Maxwell Museum(^1)</td>
<td>Approx. 300 and growing</td>
<td>1975-present</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>William M. Bass (^2)</td>
<td>1,700 and growing</td>
<td>1981-present</td>
<td>65% male</td>
<td>80% adult</td>
<td>89% white 5% black</td>
</tr>
<tr>
<td>University of Iowa/Stanford</td>
<td>1,100</td>
<td>1910-1920</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>St. Thomas Cemetery</td>
<td>579</td>
<td>1821-1874</td>
<td></td>
<td>European</td>
<td>European American</td>
</tr>
<tr>
<td>J.C.B. Grant</td>
<td>202</td>
<td>1928-early 1950’s</td>
<td>87% male</td>
<td>75% over 40 years</td>
<td>European American</td>
</tr>
<tr>
<td>Christ Church</td>
<td>968</td>
<td>1729-1859</td>
<td></td>
<td>81% adult</td>
<td>European</td>
</tr>
<tr>
<td>St. Bride’s Church</td>
<td>244</td>
<td>1761-1851</td>
<td></td>
<td>94% over 18 years</td>
<td>European</td>
</tr>
<tr>
<td>Universiteit Leiden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>European</td>
</tr>
<tr>
<td>Museu Bocage</td>
<td>1,692 and growing</td>
<td>1880-1975</td>
<td></td>
<td></td>
<td>European</td>
</tr>
<tr>
<td>Coimbra Cemetery</td>
<td>570</td>
<td>1904-1938</td>
<td>63% male</td>
<td></td>
<td>European</td>
</tr>
<tr>
<td>Dart Collection</td>
<td>2,605</td>
<td>1920’s-present</td>
<td>71% male</td>
<td>94% &gt; 20 years</td>
<td>71% SA African 18% white</td>
</tr>
<tr>
<td>Cape Town University</td>
<td>200</td>
<td>1980-1999</td>
<td></td>
<td>Most &gt; 50 years</td>
<td>African</td>
</tr>
<tr>
<td>Pretoria Gone Collection</td>
<td>290 skeletons 704 skulls 541 postcraania</td>
<td>1943-present</td>
<td></td>
<td></td>
<td>African</td>
</tr>
</tbody>
</table>

\(^1\) Updated numbers provided by Heather Edgar (personal communication).
\(^2\) Updated numbers provided by Dawnie Steadman (personal communication).
represented in the collection. Personal information from the cadavers was collected through morgue records. Individuals in this collection are 59% male and 41% female, 45% white, 54% black, and 1% other. The collection contains 461 white males, 546 black males, 323 white females, 323 black females, 5 Asiatic males, and one individual of unknown origin. Ages at death range from 16-102 years with the date of birth from 1822 to 1943. Most of the individuals in the collection are 45 years of age or older. A breakdown of age ranges by racial group is provided by the Smithsonian’s National Museum of Natural History and illustrated in Table 2.

The Terry collection contains mostly older black and white individuals from the late 19th century to early 20th century. A variety of forensic anthropology methods have been developed from this collection including sex estimation (Phenice, 1969), age estimation (Yoder et al., 2001), ancestry (Giles and Elliot, 1962), and stature estimation (Trotter and Glesser, 1952). The methods developed on antiquated collections may not be accurate for modern blank and white Americans due to physical changes that have

<table>
<thead>
<tr>
<th>Age</th>
<th>0-20</th>
<th>21-30</th>
<th>31-40</th>
<th>41-50</th>
<th>51-60</th>
<th>61-70</th>
<th>71-80</th>
<th>81-90</th>
<th>91-100</th>
<th>101-110</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Males</td>
<td>20</td>
<td>83</td>
<td>114</td>
<td>104</td>
<td>110</td>
<td>70</td>
<td>30</td>
<td>8</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>White Males</td>
<td>7</td>
<td>10</td>
<td>30</td>
<td>77</td>
<td>107</td>
<td>129</td>
<td>80</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Black Females</td>
<td>21</td>
<td>53</td>
<td>61</td>
<td>66</td>
<td>58</td>
<td>52</td>
<td>45</td>
<td>17</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>White Females</td>
<td>13</td>
<td>7</td>
<td>11</td>
<td>29</td>
<td>56</td>
<td>80</td>
<td>6</td>
<td>42</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>
occurred in these populations over time. Meadows and Jantz (1995) and Jantz and Jantz (2000) describe these physical changes to the cranial and facial forms among black and white individuals in the United States over the past 125 years. Specifically, they note a gradual lengthening of the cranial vault height and the overall narrowing of the cranial vault and facial skeleton in these populations. Additionally, individuals represented in this collection have birth dates primarily between 1850 and 1900 when Americans are recorded as having the shortest stature (Meadows and Jantz, 1995). The phenomenon of morphological change is referred to as secular change and is a result of changing environmental conditions, increased nutritional status, and overall better health.

Hamann-Todd Collection

The Hamann-Todd Collection is housed at the Cleveland Museum of Natural History in Cleveland, Ohio. In 1912, Dr. T.W. Todd, a professor of anatomy at Western Reserve University (now Case Western Reserve University), assisted by the dean of the School of Medicine, Dr. Carl Hamann, began to collect skeletons of donated cadavers used by medical students. The collection consists of 3,000 skeletons and 3,600 records of skeletons from the 19th century that include sex, approximate age, ancestry, and cause of death. The individuals in this collection consist primarily of black and white Americans of unknown ages, however, the majority of males are estimated to be older than 40 years. The ages for the specimens were largely estimated and therefore, are not ideal for age-related studies. There is a significant sex bias in this collection as 80%
of the individuals are male. White individuals make up 61% of the sample while black individuals make up 38%.

**McKern and Stewart Collection**

McKern and Stewart developed methods based on a skeletal sample comprised of soldiers who died during the Korean War. The collection contains predominantly white Americans males in their early twenties (Katz and Suchey, 1986). The ages recorded for these men are considered highly accurate as birth certificates and dates of reported death estimate them. Although a number of studies authored by McKern and Stewart and others were conducted on this sample, the methods developed reflect characteristics of young white male individuals.

**L.A. County Coroner’s Office – Pubic Symphysis Collection**

Judy Meyers Suchey collected pubic bones from 1,225 autopsied individuals at the L.A. County Department of Chief Medical Examiner-Coroner from 1977-1979. The sample was collected to develop standards to reflect ages-at-death for modern population groups. Previous pubic symphyseal age studies were developed from the Hammond-Todd and the McKern and Stewart Korean War collections and have been criticized in their application in forensic casework. The Hammond-Todd collection included individuals of unknown ages, thus studies evaluating the morphology of the pubic symphysis for age related studies using that collection are based on estimated rather than known ages (Katz and Suchey, 1986; 1989). The McKern and Stewart
collection is made up of young, predominately white males, so methods developed to age the pubic symphysis from this collection are specific only to that narrow population of individuals (Katz and Suchey, 1986).

The LA County Coroner’s Office sample consists of 739 males and 486 females of known age and race. The males range in age from 14-92 and females range in age from 13-99. Individuals in their twenties are heavily represented in this sample, followed by those in their thirties, forties, and fifties (Suchey and Katz, 1998). Fewer individuals in their sixties, seventies, eighties, and nineties are represented in this sample (Suchey and Katz, 1998). This collection was used to develop the Suchey-Brooks method for aging the pubic symphysis and is widely used in forensic practice today. The collection is currently not accessible for study.

*The Maxwell Museum Documented Skeletal Collection*

As of 2013, the Maxwell Museum Documented Skeletal Collection consists of 278 contemporary male and female individuals of varying racial backgrounds. Although only 207 of the donors have been positively identified, demographic information such as sex, age, ancestry, and cause of death for the majority of the identified individuals is known. All of the samples have been voluntarily donated to the collection or given to the museum by next of kin or the Office of the Medical Investigator when next of kin could not be located (Komar and Grivas, 2008). In 1990, a very small sample of this collection was used to develop Stanley Rhine’s quintessential study on non-metric skull
rhino selected a sample of 87 complete skulls of known identity to conduct the study. Table 3 details each group in his study.

The Rhine (1990) skeletal sample is heavily biased toward Caucasian\footnote{The terms “Caucasian,” “Negroid,” and “Mongoloid” are used here to reflect the terminology used by Rhine (1990).} male individuals with Hispanic skulls classified in Caucasian group. Both modern and prehistoric Amerindians were included for the study. It has not been shown that prehistoric Amerindians have a “typical” phenotype or that they are similar to the modern Native American population in the United States. Only seven “Negroid” skulls were assessed for the study and two of those skulls were casts of the originals. The sample population selected to document non-metric ancestry traits reflects the characteristics of a small number of select individuals underscoring the scope of

\begin{center}
\begin{tabular}{|c|c|c|c|}
\hline
Race & Male & Female & Total \\
\hline
Anglo & 40 & 13 & 53 \\
Hispanic & 13 & 2 & 15 = 68 Caucasian \\
Modern Amerindian & 3 & 0 & 3 \\
Prehistoric Amerindian & 9 & 0 & 9 = 12 Mongoloid \\
Black & 5 & 0 & 5 \\
Black Casts & 2 & 0 & 2 = 7 Negroid \\
Totals & 72 & 15 & 87 \\
\hline
\end{tabular}
\end{center}
morphological variation within and between population groups. The Rhine method does not represent the diversity of the American population and, as a result, cannot be expected to perform accurately. Despite all of the conundrums with this sample group, the traits established by this study are methodically used today, not only to distinguish racial groups, but also to serve as a baseline or set of standards for other studies to use when developing or revising a method (Birkby et al., 2008; also see: Hefner, 2009).

Komar and Grivas (2008) analyzed the Maxwell Museum donated collection to compare the demographics of the collection to relevant populations in New Mexico (living NM population, deceased NM population, and decedents with medicolegal death investigations). The results show that Maxwell Museum Donated Collection differs significantly from the three populations compared in that (1) males are overrepresented, (2) age cohorts are disproportionate with those over 45 are over represented with more than 20% of the collection being over the age of 80, and (3) white individuals are overrepresented while Native American and Hispanics being significantly underrepresented. In addition, 60% of the individuals represented in the Maxwell Museum collection are labeled with population affinities determined by a pathologist at autopsy or the collections curator, not self-reported or reported by family (Komar and Grivas, 2008).

William M. Bass Donated Skeletal Collection

In 1981, Dr. William M. Bass began curating a collection of skeletons from individuals donated to the Forensic Anthropology Center at the University of Tennessee
in Knoxville, Tennessee. The modern-day collection consists of over 1,700 individuals and each year, approximately one hundred of new donations are added (Steadman, personal communication). Individuals in this collection are predominantly from Tennessee and as such, reflect the demographics of this area. Wilson et al. (2007) found that self-donors had higher education levels and represented a higher socioeconomic class than those donated by family or by a medicolegal authority. The sample is biased toward older white males (Wilson et al., 2007) although black, Asian, and Hispanic individuals of both sexes are represented in smaller numbers. In addition, 47 cremated individuals are available for study. This collection represents the largest sample of modern-day Americans and is a common location for students and academics to conduct osteological research.

**Special Considerations for Reference Collections**

This review of skeletal reference collections is limited to only a few of the more recognizable and widely used American collections in forensic anthropology. Many more collections have amassed over the years to help researchers expand research goals and interests and also perform validation studies. The descriptions of these key collections should be kept in mind when evaluating the efficacy of the methods used to estimate the biological profile because The SWGANTH recommendations and best practices for estimating the biological profile emphasize the use of appropriate population-specific standards. Therefore the forensic anthropologist must understand
the strengths and limitations of methods used and the population demographics from which the methods are derived.

Nevertheless, several researchers have suggested that the Terry and Hamann-Todd collections are not representative of modern populations due to secular change (Ousley, 1995; Meadows and Jantz, 1995; Erikson, 1982; Ousley and Jantz, 1998, 1992; Dirkmaat et al, 2008). Although some methods, notably sex estimation methods developed from reference collections are widely applicable (Klales et al., 2012; Klales, 2016), Hoppa (2000) noted that there is a difference in aging processes among samples and points out that one reference sample does not work for estimations of age in all populations. Kemkes-Grottenthaler (2002) similarly notes that there may be biological differences among population groups that affect aging processes, particularly among females. Further, Kimmerlee et al. (2008) found that there are differences in aging processes in females among American and Eastern European populations. Langley-Shirley and Jantz (2010) found that the clavicles of modern Americans fuse 4 years earlier than 20th century Americans and 3.5 years earlier than Korean War era Americans. Finally, anthropological methods to estimate ancestry developed from limited samples does not encompass the wide range of variation seen in modern population groups (Komar and Grivas, 2008; Albanese and Saunders, 2006; Spradley et al., 2008).

In addition, it is not enough to discuss the reference collections themselves without considering the donation bias that exists with the collections. Komar and Grivas (2008) outline sources of donation bias including the cultural and religious acceptance
of body donation and the socioeconomic status of donors. These factors, they argue, selectively bias the collection and should not be used as proxies for modern populations (Komar and Grivas, 2008). Further, when a subsample of individuals are selected from a skeletal reference collection, or from many skeletal reference collections (in the case of the Forensic Data Bank), it cannot be considered representative of modern populations because the samples selected are drawn from collections that suffer from this formation bias (Komar and Grivas, 2008).

**Sex Estimation**

Anthropologists have long recognized that there is a difference between sex and gender and that sex is not a binary characteristic. Sex refers to the biological sex of an individual: male and female based on physical characteristics controlled by genetic expression. These biological traits vary in their degree of expression. Gender, on the other hand, is a cultural construction of identity independent of primary and secondary biological sex characteristics. Forensic anthropologists rely on biological sex characteristics to determine the sex of human remains because only biological sex can be extrapolated from skeletal materials. The sexing of adult skeletal elements is one of the most important aspects of the biological profile because it narrows the pool of potential victims by half and influences all other components of the profile (ancestry, age, and stature). Because males and females display varying degrees expression in
traits used to estimate other components of the biological profile, sex is often the first feature anthropologists estimate.

Sex estimation can be conducted with both metric and non-metric analyses of the pelvis and skull as well as through metric analysis of the postcranial elements (France 1998, Spradley and Jantz, 2011). Sexing the adult skeleton relies on the discrimination of the physical size and shape differences between males and females. As such, sex can be reliably determined from the morphological features of the pelvis because the differences observed between males and females in the pelvic region are due to the function of childbirth in females (Bass, 1995; Phenice 1969; White et al., 2012). In general, females have wider and broader os coxae to allow for the passage of an infant though the birth canal, while males have narrower and longer os coxae (Buikstra and Ubelaker, 1994; Phenice; 1969). Phenice (1969) developed a visual method for sexing the os pubis utilizing three landmarks. When tested, the accuracy rate for this method is reported to be between 70% and 96% in controlled experiments (Sutherland and Suchey, 1991; Ubelaker and Volk, 2002). Recently, a revised Phenice method developed by Klales et al. (2012) demonstrates 94.5% accuracy in the sample population and 86.2% in an independent validation sample. Additional validation studies of this method on South African samples found the method correctly classified sex in 99.2% (Kenyhercz, 2012) and in 97.59% (Stull et al., 2013) of individuals sampled. Additionally, validation of this method on a sample of modern forensic cases demonstrated 90.9% classification accuracy (Kenyhercz et al., 2012).
Other morphological characteristics of the pelvic bone that are indicative of an individual’s biological sex include the shapes and size of the pubic bone, greater sciatic notch, obturator foramen, the presence or absence of the preauricular sulcus (Bass, 1995; Steadman and Anderson, 2009), and to a lesser degree the presence or absence of parturition scars (Kelley, 1979). The ventral arc, subpubic concavity, ridge of the ischiopubic ramus, greater sciatic notch, and preauricular sulcus are characteristics that can be scored on an scale of 1 to 3, with 1 representing the morphology of females and 3 representing males (Buikstra and Ubelaker, 1994). It is important to note that, sex estimation techniques developed from the pelvis and skull have largely been limited to samples of black and white Americans (Rogers and Saunders 1994; Rogers 2005; Walker, 2005; Williams and Rogers, 2006; Walker, 2008). Although most population groups exhibit predicable sexually dimorphic traits, some Asian and Hispanic groups are generally gracile and differences between males and females can be harder to detect (Birkby et al., 2009; Rogers and Saunders, 1994). This poses a challenge for forensic anthropologists attempting to estimate the sex of individuals from populations where sexual dimorphism is less pronounced. Additionally, in relatively heterogeneous areas, where the population demographics consist of a variety of diverse groups, the estimation of sex is less straightforward, particularly if ancestry is not known.

The skull is another sexually dimorphic portion of a skeleton. The skull demonstrates differences between males and females and the examination of the size and rugosity of muscle markings and other characteristics can be useful for sex estimation (Buikstra and Ubelaker 1994; White et al., 2012). Sex estimation of the
cranium also depends on the degree of sexual dimorphism existing within population groups. Regardless, the common morphological traits used for sex estimation of the skull include the size and rugosity of the muscle attachments associated with the nuchal crest, external occipital protuberance and mastoid processes (Bass 1995; Walker, 2008). The shape and size of the supraorbital ridges, supraorbital margins, forehead, chin, and the gonial angle can also be used to infer sex (Bass 1995; Walker, 2008).

Additionally, measurements of the skull are often utilized for statistical analysis (Bennett, 1993; France, 1998) and can be entered into FORDISC 2 for discriminant function analysis (Ubelaker, 1998). FORDISC is a statistical computer program that utilizes discriminant function analysis to compare the unknown individual against the existing database of known males and females. The program will utilize measurements of the skull to classify the unknown individual into a male or female category. Although FORDISC 2.0 will classify the sex of an individual independent of ancestry, FORDISC 3.0 will not classify sex independent of ancestry (Guyomarc'h and Bruzek, 2011).

Estimation of sex from postcranial elements can be useful for cases where the pelvis, skull, or both are missing or in cases where sex estimation from the skull or pelvis is inconclusive. Although the skull is often considered to be the second best option for sex estimation (Bass, 2005; Byers, 2002; Pickering and Bachman, 1997), numerous studies (Berrizbeitia, 1989; France 1998; Robling and Ubelaker, 1997, Tise et al., 2013) suggest otherwise. Spradley and Jantz, (2011) conducted univariate and multivariate discriminant models on postcranial elements from the Forensic Data Bank and reported that most postcranial elements outperform the skull in estimating sex.
Measurements of postcranial elements can be entered into FORDISC for metric analysis and, like the skull, will be compared against the existing database of known males and females. Methods utilizing metrics can be useful if the appropriate data is available for the population group considered for analysis. As with non-metric approaches, many metric postcranial sex estimation methods rely on limited sample sizes primarily consisting of black and white Americans.

While attempts have been made to develop techniques to reliably estimate the sex of subadult skeletal remains, these techniques are not generally accepted. The features and characteristics detailed above for adult sex estimation do not typically appear in juveniles until the onset of puberty or the onset of secondary sex characteristics (both of which vary on an individual basis). Genetic analyses of amelogenin are especially useful in juvenile cases (Gibbon et al., 2009).

The SWGANTH sex assessment (2010) document recommends anthropologists employ the following best practices to estimate sex from skeletal remains:

- Sex assessment should be made independently of suspected or presumptive identification to avoid bias.
- When appropriate, use population and period-specific standards.
- Assess and measure the maximum number of age-appropriate cranial and postcranial variables, emphasizing the most dimorphic elements present, especially in the case of fragmentary remains.
- Document and describe the location of any inconsistent indicators.
• If an observation cannot be made or a measurement cannot be taken, explain its absence: missing, broken, fractured, congenital, pathological, or anomalous.

• Sex assessment, as well as assessments of other skeletal parameters, should be performed, even if samples for DNA analyses will be taken.

• Express degree of certainty when reporting sex assessments, especially when a sex assessment is less than certain, e.g. “male?”

• When an assessment of skeletal sex is not possible (e.g. partial remains or those of subadults), sex assessment by DNA analysis may be helpful.

Age Estimation

The estimation of age at the time of death is an important component of the biological profile. Along with sex, an accurate age range serves to narrow the pool of potential victims among missing individuals (Krogman, 1962; Iscan et al., 1984a; Iscan et al., 1984b; Meena et al., 2012, 2013; Wolff et al., 2012). There exist different methods for age estimation of juvenile versus adult individuals. Juveniles are aged by the interpretation of growth and development processes, while adults are aged through the interpretation of degenerative processes of the skeleton.

Juvenile Age Estimation

Juvenile age estimation from skeletal remains generally relies on changes related to growth and development such as dental mineralization and eruption and long
bone growth and epiphyseal fusion. Dental development is a highly conserved trait, strongly controlled by genetics, and dental development patterns have been well documented (see Moorrees et al., 1963; Schour and Massler, 1941, 1944; Ubelaker, 1999; Scheuer and Black, 2000; Saunders, 2000; Fitzgerald and Rose, 2000). Assessments of developmental patterns provide accurate and reliable subadult age estimations. While dental mineralization is considered the most accurate method for aging sub adults, tooth eruption patterns are also informative. However, eruption patterns are more variable than developmental patterns (Ubelaker, 1989), for example, the third molars (wisdom teeth) are considered unstable and highly variable, even absent (agenesis) in some individuals.

Forensic anthropologists can reliably estimate subadult age from dentition up to approximately 15 years of age, when the roots of the second molars finish developing. Although dental age indicators are highly conserved genetically, they are not resistant to environmental influences that may affect development. Cardoso (2008) and Hueze and Cardoso (2008) attribute socioeconomic status with the disturbance of dental development.

Growth and development (epiphyseal fusion) of long bones can also a reliable age indicator for juvenile remains (Stewart, 1979; Scheuer and Black, 2000). Bones grow and develop at predictable rates and epiphyseal fusion occurs on different bones at different, but generally known, timeframes (Scheuer and Black, 2000). For example, Webb and Suchey (1985) found that the medial clavicle and anterior iliac crest are the last elements to fuse. The medial clavicle will fuse between 20-34 years for females
and 21-31 years for males while the anterior iliac crest will fuse in females between 18-24 years of age and 17-24 years for males. Most recently, Langley-Shirley and Jantz (2010) developed confidence intervals using a Bayesian approach to document the age of transition between phases of clavicle fusion in modern American males and females. These reliable age markers allow anthropologists to accurately calculate the age interval of individuals, particularly those over 15 years of age, when dental indicators become less reliable. However, Saunders (2000) noted that subadult females age faster than males and, akin to dentition, Cardoso (2008) reported that socioeconomic status would affect subadult skeletal growth rates. Lower socioeconomic status is a key variable in the differential growth patterns observed in subadult skeletal materials that may impact rates of skeletal maturation (Kim et al., 2008; Malina, 1979; Bagga and Kulkarni, 2000; Low et al, 1982; Laska Mierzejewska et al, 1982; Rimpela and Rimpela, 1993; Prado, 1984; Cardoso, 2008; Abioye-Kuteyi et al, 1997; Alberman et al, 1991; Bodzsar, 2000; Todd, 1937; Meijerman et al, 2007).

Adult Age Estimation

Adult age estimation relies on the interpretation of degenerative changes that manifest in the skeleton. Physiological age related changes are documented in skeletal reference collections and correlated with chronological age ranges. Age related changes are chronological but their degree of manifestation can also be affected by life experiences. Age estimation, therefore, is presented as a range of years (e.g. 30-45...
years of age) because aging techniques rely on the anthropologist’s ability to interpret these highly variable degenerative skeletal changes. While most people progress through the “phases” associated with different age ranges, the rate of progression, or the rate of aging, is influenced by genetic and environmental factors (Berg, 2008; Meena et al., 2013).

Following the development and complete fusion of bones, forensic anthropologists analyze the morphological changes of joint surfaces over time to provide a statistically derived age range. Currently, adult age estimation techniques depend on the analysis of joint surfaces not affected by stresses associated with body weight, locomotion, or muscle attachments. Baring any trauma to the joint, the pubic symphysis is ideal for age estimation because it is resistant to activity related stress. The sternal rib ends (Iscan, 1984a, 1986a, 1986b) and the auricular surface of the ilium (Lovejoy et al, 1985; Buckberry and Chamberlain, 2002) are also resistant to activity related stress and can also be used to estimate age. In addition to the analysis of joint surfaces, dental attrition (Lamendin et al., 1992) and cranial suture closure (Meindl and Lovejoy, 1985) are also used for adult age estimation. Besides the best practices outlined by SWGANTH, there is no anthropological standard for aging the adult skeleton. Garvin and Passalacqua (2012) found that 78% of 145 forensic anthropologists responding to a survey prefer the pubic symphysis for age estimation followed by the sternal rib ends and the auricular surface of the ilium, respectively. Cranial sutures and dental attrition were least preferred (Garvin and Passalacqua, 2012).
The most commonly cited and used pubic symphyseal aging methods in anthropology are the Suchey-Brooks method (Katz and Suchey, 1986, 1989), the McKern and Stewart method (1957), and the Todd methods (1921a, 1921b). In forensic anthropological casework, the Suchey-Brooks method is preferred (Hartnett, 2010; Fleischman, 2013), as it is sex specific and derived from 1,200 modern American individuals of various ages collected from the Los Angeles County Office of the Coroner. The McKern and Stewart (1957) and Todd methods (1921a, 1921b) are not commonly cited in forensic casework as they were developed from the McKern and Stewart Korean War sample and the Hammond-Todd collection. The Defense POW/MIA Accounting Command (DPAA) and other non-profit organizations that analyze the remains of deceased US servicemen of past wars more commonly employ these methods because they reflect age related changes of persons living around the beginning of the 20th century. As discussed earlier, these collections are not appropriate for age analysis of forensic cases because the sample populations used to derive the methods, being developed on antiquated populations, do not reflect the population of the unidentified remains. Although the Suchey-Brooks method is widely used in forensic contexts, studies indicate that the method’s accuracy is limited due to the use of wide age ranges. The wide age ranges help to ensure that the unknown’s chronological age is included so to not unintentionally exclude potential matches. Moreover, this method has proved to perform better on skeletal materials of younger individuals than older individuals due to variation in the degeneration process of individuals (Martrille et al., 2007; Berg, 2008; Hens et al., 2008; Kimmerle et al., 2008;
Overall the Suchey-Brooks method has low evidentiary value (Konigsberg et al., 2009) primarily due to wide age intervals and the large amount of variation within stages. Konigsberg et al. (2009) further note that the method is applied better than expected at random, “however with only six stages, it cannot be expected to provide much information for identification purposes” (Konigsberg et al., 2009:554).

The auricular surface of the ilium is another area of the pelvis used for forensic age estimation, (Lovejoy et al., 1985; Buckberry and Chamberlain, 2002) although is not commonly used in casework. The auricular surface is the non-weight bearing joint where the sacrum articulates with the broad surface of the ilium on the anterior-superior surface of the bone. Similar to the methods developed for the pubic symphysis, the auricular surface technique is used to evaluate joint surface degeneration over time to provide an age range. The Lovejoy et al. (1985) method was developed for archaeological purposes from the 19th century Todd and Libben collections and describes 8 phases with 5-10 year age ranges, but provides no error statistics. Murray and Murray (1991) tested the method on the Terry Collection to see if the methods could be used in modern forensic cases, Bedford et al. (1993) tested the method on the Grant Collection at the University of Toronto, Schmitt (2004) tested the method on a collection of 66 Asian individuals and Saunders et al. (1992) tested the method on an archaeological sample with known ages at death. All four studies found that the method consistently underestimated the age of older individuals and overestimated the age of younger individuals. Murray and Murray (1991) attributed these findings to differences in age structures between the collections. Bedford et al. (1993), Schmitt (2004), and
Saunders et al. (1992) found that the method performed better for younger individuals, underestimated the age at death for older individuals and had a high interobserver error. Saunders et al. (1992) attributed these findings to the inability of the method to encompass variation in skeletal aging. Buckberry and Chamberlain (2002) sought to improve the accuracy of the auricular surface method and modified Lovejoy et al. (1985) to include a quantitative scoring system. Their approach, although easier to apply, lacks error rates and includes large age ranges that encompass all of adulthood (e.g., 16-65 years and 29-88 years). Overall, methods utilizing the auricular surface of the ilium are difficult to apply and result in wide age intervals that, although may include the age of the unknown individual, are not narrow enough to be useful to law enforcement; with the exception of Lovejoy et al. (1985) where the age ranges are too narrow to encompass individual variation.

Garvin and Passalacqua (2012) note that sternal rib end analysis for age estimation is the second most preferred technique by forensic anthropologists. The sternal rib ends offer sex-specific age phases with narrower age ranges than the Suchey-Brooks method and the technique is easy to apply (Meena et al., 2013). Additionally, unlike the os coxae, rib ends are not subjected to the stresses of pregnancy in females. Iscan et al. (1984a) and Iscan and Loth (1986a, 1986b) conducted a series of studies on the morphological changes of the sternal end of the right fourth rib for males and females. This method, developed with a modern U.S. sample from Medical Examiner’s Offices, provides full statistical analyses. The age related changes that can be observed from the fourth rib have provided reliable age
estimations (Saunders et al., 1992; Iscan and Loth, 1997) and can be applied to ribs 3-6 on both sides of the body (Yoder et al., 2001). However, Cerazo-Roman et al. (2014) found that the method consistently underestimated the age of a Mexican population. Unfortunately, the sternal ends of the ribs are fragile and not always preserved in forensic contexts. Damaged ribs resulting in the differential preservation or destruction of the sternal surface are caused by a variety of factors including perimortem trauma and taphonomic conditions such as postmortem fracturing, animal activity, and weathering. Thus, poor preservation of the fourth rib may preclude age estimation using this method.

When only the cranium is available, cranial suture closures and dental attrition can be analyzed. Analysis of cranial suture closures can be conducted on ectocranial (Meindl and Lovejoy, 1985) and endocranial (Todd and Lyon, 1924) sutures. Cranial suture analysis is controversial because cranial suture closure is highly variable among individuals. The method is also generally considered unreliable and difficult to apply, and is used when other options have been exhausted. However, dental aging methods have shown some promise. Cameriere et al. (2004) have developed a protocol for dental aging that presents high levels of accuracy for adult individuals, particularly those over 30 years of age. This method assesses chronological age based on the correlation between age and the pulp/tooth area ratio in single-rooted teeth. Forensic odontologists utilize radiographic images to analyze tooth morphology, which places estimated ages of adult individuals within months of their actual ages.
Adult aging methods and techniques were primarily developed on skeletal collections comprised of black and white Americans. Degenerative changes are variable within and between adult individuals due to a variety of factors including lifestyle, health, nutrition, and genetics (Crews and Garruto, 1994). Marginalized groups lacking consistent access to healthcare and proper nutrition may deviate from the age standards developed from these skeletal collections. Moreover, the error rates of many aging techniques are unknown making age estimation problematic for forensic application and expert witness testimony. SWGANTH (2013) recommends anthropologists employ the following best practices when estimating age from skeletal remains:

- Whenever possible, standards for age assessment should be used that are most appropriate for the ancestry/population origin of the remains examined. Both sex-based and ancestry-based variation exists in dental and osteological development. When population-specific standards are not available, standards that are more inclusive (and with greater variance) should be used, and those standards should be documented in the report.

- Practitioners should have extensive knowledge of skeletal anatomy and experience with the various methods of age estimation. This includes both experience in the technique used during age estimation, as well as experience with osteological material. The analyst should be knowledgeable about the ranges of normal human variation in the teeth and skeleton. They should be
attentive to pathological conditions that might have an effect on traits used for aging purposes, especially degenerative changes.

- The final age estimate is a matter of expert judgment by synthesizing all available information. Factors to be considered are: appropriateness of the reference data, skill in using one method over another, condition of the remains, applicability of statistical models, etc.

**Ancestry Estimation**

Several methods have been developed over the past 60+ years, to estimate ancestry from skeletal remains (For a small sampling, see: Rhine, 1990; Gill et al., 1988; Gill, 1998; Birkby et al., 2008; Burris and Harris, 1998; Edgar, 2005; Fransciscus and Long, 1991; Hanihara, 1996; Hefner, 2009; Hughes et al., 2011; Wescott and Moore-Jansen, 2001). Although methods have been developed for numerous skeletal elements, the skull has been identified as the most useful area of the skeleton for ancestry estimation (Howells, 1973; Rhine, 1993).

Morphological trait analysis is a common technique with a long history in the anthropological literature (see Rhine, 1990), and its supposed ease of implementation (Albanese and Saunders, 2007). Ancestry estimation methods using the interpretation of morphological traits are based on the idea that these characteristics are heritable (Relethford, 2002; Havarti and Weaver, 2006; Carson, 2006; Devor, 1987), although they vary in degrees of expression (Hughes et al., 2011). The numerous methods
developed to interpret skeletal clues of ancestry require the observer to have extensive experience using the methods on a large and varied sample of skeletal remains (Hefner, 2007, 2009; Hefner et al., 2001; Wheat, 2009; Hooton, 1926, 1946; Hinkes, 1993; Rhine, 1990; Stewart, 1979).

There are two main types of morphological trait assessment that rely on visual evaluation of skeletal characteristics: anthroposcopic traits and non-metric traits (Albanese and Saunders, 2006). Anthroposcopic traits are those that are present in varying degrees on all skeletons utilizing an ordinal-scale to record their degree of expression, while non-metric traits are those that can be determined by their presence or absence in skeletal materials (Albanese and Saunders, 2006).

Examples of anthroposcopic traits include the shape of the dental arcade, the degree of prognathism, the shape of the nasal aperture, the protrusion of the nasal spine, and the projection of the zygomatic bones. Non-metric trait examples include the presence or absence of the malar tubercle, shovel-shaped incisors, and Carabelli’s cusp.

Note that the terms anthroposcopic traits and non-metric traits are often conflated in the forensic anthropological literature and used interchangeably (Albanese and Saunders, 2006). For example, Byers (2005) in an introductory forensic anthropology textbook refers to all traits as anthroposcopic, Gill (1995) terms all traits non-metric, Hughes et al. (2011) refers to anthroposcopic traits as morphoscopic traits and non-metric traits as binary traits and Hefner (2009) refers to traits as non-metric or morphoscopic. Despite differences in terminology, all of these skeletal traits are
believed to tell us something about the ancestral origin of the individual because skeletal traits are heritable and found to be common among regional population groups (Hooton, 1926; Boyd, 1950; Brues, 1977; Bamshad et al., 2003; Cheverud, 1982, 1988; Cheverud and Buikstra, 1981, 2005; Ishida and Dodo 1993; 1997; McGrath et al., 1984). Descriptions of skeletal traits can be attributed to the work of Earnest Hooton, a physical anthropologist at Harvard University. In the 1920s he developed the “Harvard List,” a list of cranial non-metric traits for skeletal analysis (Brues, 1990; Hefner, 2009). Many of the traits identified by Hooton are used today in forensic practice and provide a theoretical and practical foundation for modern ancestry estimation methods (Birkby et al., 2008; Hefner, 2009).

Rhine (1990) in his article “Non-Metric Skull Racing” summarized morphological traits from the Harvard List commonly used by anthropologists to estimate the ancestry of unidentified individuals (Rhine, 1990; Smay and Armelagos, 2000). Additionally, he addressed the varied and unstandardized criteria used for ancestry estimation among practicing anthropologists in an attempt to standardize morphological trait assessment (Rhine, 1990). He tested 45 traits of the skull and developed a trait list with illustrations that can be used to separate individuals into three groups: American Caucasoid, Southwest Mongoloid, and American Blacks. Despite being a resource that is considered to have had a “major influence on American forensic anthropology” (Birkby et al, 2008:30) and is “useful today” (Birkby et al., 2008:30), the study has serious methodological flaws as it is based on a limited skeletal sample, uneven subsamples, and heavily biased toward white individuals (Albanese and Saunders, 2007; Smay and
Moreover, suspected Hispanic skulls were grouped into the white category (Birkby et al., 2008), casts of black skulls in place of real skulls were used in the analysis, and traits were assigned based on anecdotal experiences of the few study participants (Rhine, 1990). Since Hispanic individuals were grouped into the white sample in Rhine’s (1990) study, Birkby et al. (2008) sought to provide a series of non-metric traits frequently observed among the undocumented border crossers along the southern border of the United States. The authors note that this population of Hispanic individuals displays a suite of characteristics observed in both European and Native American populations (Birkby et al., 2008).

Further studies of non-metric trait analysis expanded on the methods developed by Rhine (1990) but typically compared skeletal traits of just two groups such as black and white or white and Native American (See: Gill et al., 1998; Burris and Harris, 1998; Wescott and Moore-Jansen, 2001; Edgar, 2005; Yokley, 2009; Klales and Kenyhercz, 2015). However, these studies oversimplify the variation that exists among the American population by comparing few population groups. Furthermore, the assignment of morphological traits is largely based on assumptions about the apportionment of human diversity. Articles such as Rhine’s (1990) and Gill’s (1998) demonstrate a typological approach to the assessment of ancestry. However, typological studies like Rhine (1990) do not explicitly capture group differences and he noted that classification of the samples could be problematic. Further, Rhine (1990) found large amounts of variability in the sample groups with 37 out of 45 traits occurring with frequencies up to 30% in more than one group.
To address concerns that typological methods oversimplify the frequency of variation between population groups, Wescott (2005) and Hefner (2009) describe and quantify the frequency of morphological traits that have been found to occur in more than two groups. Studies like these attempt to understand the varying frequencies of traits within populations and are a step in the right direction, but are affected by the sample groups selected from reference populations. Wescott (2005) evaluated within and between group variation of proximal femur shape in five groups: American Whites, American Blacks, Native Americans, Hispanics, and Polynesians. However, the samples selected may not represent contemporary forensic casework. The Native American sample is comprised of historic and prehistoric individuals, the Hispanic population is from the Forensic Data Base (FDB) where no specifics regarding their ancestry is known (Wescott, 2005), the American black and white samples are from the Terry collection and the FDB, and the Polynesian group is an archaeological sample of Hawaiians. Likewise, Hefner (2009) used population groups for his analysis of cranial traits that may not represent the variation of individuals in forensic casework. For example, the African sample was collected from Africa in 1909, the American black and American white samples were taken from the Terry collection, the Asian sample represents individuals from the 1800s, and the Native American sample represents prehistoric and protohistoric individuals (Hefner, 2009). These studies document trait characteristics and frequencies within several population groups, but the sample collections used are not contemporary.
Metric analysis, on the other hand, utilizes instrumentation to measure skeletal elements. Measurements of unknown skeletal remains can be compared to the dimensions of known individuals recorded in a database. Ideally, measurements are taken from complete or mostly complete sets of skeletal remains for analysis. The analysis of skeletal measurements is considered to be more objective than morphological evaluation of skeletal traits, as the results are quantifiable pieces of data devoid of observer subjectivity. As such, metric programs like FORDISC have improved in accessibility and usability over the years and have become a viable tool for the forensic examiner.

**FORDISC**

FORDISC 3.0 is the latest generation of computer statistical software that uses Linear Discriminant Function Analysis (LDFA) to estimate sex and ancestry (Jantz and Ousley, 2005), and linear regression to estimate stature (Ousley, 2012). In 1985, the National Institute of Justice (NIJ) awarded Dr. Richard Jantz a grant to establish the Forensic Data Bank (FDB) (Jantz and Ousley, 2013). The FDB consists of metric data from forensic cases and skeletal collections that mostly have documented demographic information such as date of birth, medical history, occupation, measurements, and non-metric traits (Jantz and Ousley 2013). In addition to containing information from the most well-known and extensive collection of modern humans, the William M. Bass donated collection curated at the University of Tennessee; the Smithsonian Institution and the University of Mexico have also contributed skeletal data. Metric data from
forensic cases by practicing anthropologists are also regularly submitted for inclusion in the database. The creation of the FDB was encouraged by research documenting secular change in the American population (see: Meadows and Jantz, 1995; Jantz and Jantz, 1999; Jantz and Jantz, 2000).

FORDISC is a common tool to analyze metric data by forensic anthropologists and researchers worldwide (Ousley and Jantz, 2005) and forensic anthropologists at the NYC-OCME, the Pima County Office of the Medical Examiner, and the Harris County Institute of Forensic Sciences regularly use the program for their casework. Data from an unknown individual is entered into the program and will be classified into one of the groups represented in the database. The program requires the user to be proficient in taking correct measurements to input into the program and to interpret the results accurately.

Historically, Giles and Elliot (1962) were the first to apply a 3-way LDFA to calculate ancestry among a small population of white and black Americans and American Indians (75 each). Research on secular change suggested that LDFA would not be accurate in the forensic analysis of contemporary human remains because (1) they require analysis of non-fragmented human remains and (2) the samples themselves are limited to black and white Americans born in the 19th century and American Indians from the Indian Knoll site (3000-2000 BC) in Kentucky (Jantz and Ousley, 2013). Because forensic cases vary in the number of recovered skeletal elements and the condition of recovered elements, LDFA is limited in its utility. Furthermore, since the American population is undergoing secular change and the
Indian Knoll site is representative of a small group of Native Americans, the formulae developed by Giles and Elliot may not accurately reflect a forensic population.

FORDISC 3.0, however, was designed to perform a number of functions that can be useful not only to forensic anthropologists, but to anyone conducting research on modern humans. According to Jantz and Ousley (2013), the program's use is widespread and Dirkmaat et al. (2008) state that nearly every practicing forensic anthropologist utilizes the program. Further, various researchers across the world have utilized the program (see: Marquez-Grant, 2005; Lambert, 2006; Verhoff et al., 2008; Leach et al., 2009; Seidemann et al., 2009; Guyomarc'h and Bruzer, 2011; Urbanova et al., 2014). Additionally, anthropologists in private and governmental agencies use FORDISC to analyze historical remains and the Defense POW/MIA Accounting Agency uses it to help identify American war dead (DPAA SOP 3.4, 2015). As an additional tool, the program also contains Howell’s published worldwide data set of past populations, the Terry collection, and Hamann-Todd collection so that users studying historic samples can also benefit from the program.

FORDISC is a user-friendly program that provides forensic anthropologists with computationally derived results based on statistical models (Urbanova et al., 2014). Linear discriminate function analysis allows the researcher to use combinations of skeletal measurements to classify individuals into biological categories such as sex and ancestry based on the sample contained within the database. The user can also choose to perform a number of statistical analyses, which identifies the most suitable measurements for a particular examination.
As noted earlier, quantifiable scientific analysis is preferred in the courtroom and metric analysis provides forensic anthropology with tools, such as FORDISC that are required to meet the ever-increasing demands of evidentiary standards (Dirkmaat et al., 2008). The success of the program can be seen today, 20 years after its creation, as there are currently over 4,081 individuals recorded in the FDB and over 2,400 with recorded sex and ancestry. The FDB is a living document that continues to grow with the continuous additions of donated remains from the University of Tennessee’s Anthropological Research Facility (ARF) and other outside agencies, including undocumented border crosser cases from the Pima County Office of the Medical Examiner. In all, 100 laboratories have contributed cases to the database (Jantz and Ousley, 2013).

Although FORDISC is a powerful computer program, it has significant limitations and has been criticized (see: Elliott and Collard, 2009; Guymarc’h and Bruzek, 2011; Kosiba, 2000; Ubelaker et al., 2002; Williams et al., 2005; Armelagos and Van Gerven, 2003), particularly when used to estimate ancestry (Kosiba, 2000; Williams et al, 2005; Elliott and Collard, 2009; Belcher et al, 2002; Hubbe and Neves, 2007; Keita, 2007; Pritchard, 2007). The program operates under the assumption that measurements of the skull are unique to different population groups and that these measurements undergo few changes over time (Williams et al., 2005; Hubbe and Neves, 2007). FORDISC, therefore, attempts to classify individuals into racial groupings based on measurements belonging to the groups represented in the database. Despite the limitations of its applications, the program is widely regarded as a powerful tool for
forensic analysis (Ubelaker et al., 2002). The following examples feature some of the concerns researchers encounter when using FORDISC to assess sex and ancestry.

A study published in 2007 by Ramsthaler et al. (2007) utilized FORDISC 3.0 and morphological assessment to estimate the sex of a sample of 98 modern German Caucasian crania of known sex and age from forensic cases. Discriminant function analysis of biological sex using FORDISC resulted in an average accuracy of 86% for both sexes, while morphological analysis yielded an average accuracy of 94% for both sexes. The authors recommend that morphological analysis, not FORDISC be used for individuals of European descent until a proper reference population is entered into the database. The authors caution that even with a good classification rate (86% in this sample), if a forensic case differs from the reference population in the database, it should be also evaluated morphologically. The reason is simply because morphological assessment of the skull was more accurate than FORDISC to estimate sex in this sample (Ramsthaler et al., 2007). Since FORDISC 3.0 does not allow the user to evaluate sex without ancestry, they emphasize that it may be difficult or impossible to even know if the ancestral group of the unknown forensic case is represented in the database, thus, providing more reason to assess the morphological sex characteristics of the skull in addition to using FORDISC (Ramsthaler et al., 2009).

In 2011, Guyomarc’h and Bruzek conducted a study on a known sample of French and Thai individuals to test FORDISC 3.0’s accuracy for sex estimation. Again, since FORDISC 3.0, unlike its predecessor 2.0, does not allow for the independent assessment of sex or ancestry, both must be considered together. This created an
unnecessary problem for the European researchers because they do not rely on ancestry estimations in forensic analysis to the degree that Americans do (Guyomarc’h and Bruzek, 2011). Regardless, the need for discriminant function analysis to be population specific is generally understood in the forensic community (see: Bidmos and Dayal, 2004; Kemkes-Grottenthaler, 2005; Gualdi-Russo, 2007). However, in forensic casework, it is not always known which ancestral group an unknown individual belongs to, making sex analysis dependent on ancestry impractical. In addition, if the unknown’s ancestral group is not represented in the database, or is represented in low numbers, the results for sex and ancestry may not be accurate. In reference to this problem, Elliot and Collard (2009) state, “the nature of discriminant function analysis is such that the program can only be expected to perform adequately if a specimen’s source population is represented in the reference sample.”

Studies conducted by Ubelaker et al. (2002) and Williams et al. (2005) underscore the difficulty of assigning ancestry to ancient skeletal samples (see also Belcher et al., 2002; Fukuzawa and Maish, 1997 and Leathers et al., 2002). Although FORDISC is not intended to classify archaeological specimens, the results of these studies are evaluated here to evaluate the ongoing debate of the program’s effectiveness. The Ubelaker et al. (2005) study attempted to classify 50 individuals from a sample derived from a 16th and 17th century Spanish cemetery. FORDISC, using the Howell’s dataset, categorized these individuals into 21 distinct groups ranging from Austria, Egypt, Hungary, Norway and half of the sample from Asia. This is not the outcome that was expected with a homogeneous Spanish sample and likely due to the
lack of a Spanish sample in FORDISC. However, almost half of the sample classified into groups with no geographic or ancestral relationship to the Spanish sample (Ubelaker et al., 2002). In addition, size factors within the Spanish sample resulted in the incorrect sex estimation of males, with 57% classifying as females further emphasizing the importance of morphological sex estimation in addition to computational methods. Unsatisfied with the accuracy of the results, Ubelaker and colleagues agreed with Ousley and Jantz (1996) that FORDISC should be used with caution, particularly when assessing individuals with ancestries not represented in the database. Again, this condition is tricky for forensic anthropologists who do not know the ancestry of an unknown individual and do not know if the group the unknown belongs is represented in the database.

In 2014, Urbanova and colleagues echoed the concerns of Ubelaker et al. (2005) by testing FORDISC’s ability to correctly classify 147 crania of Brazilian origin composed of different ancestral groups, including European Brazilians, Afro-Brazilians, and Japanese Brazilians and Brazilians of admixed ancestry. Since there is not a Brazilian sample in FORDISC, the point of this study was “to stress the limitations when an individual that falls outside the targeted reference sample is to be entered” (Urbanova et al., 2014:269). However, since ancestral origins of the Brazilians were known (e.g. European Brazilians, Afro-Brazilians and Japanese Brazilians) it was expected that the crania would classify into the European, African, and Asian parental groups, respectively. The results showed that FORDISC 3.0 analysis was only able to correctly classify 44% of the sample using Howell’s dataset and 50% of the sample
using the FDB. In particular, Afro-Brazilian and admixed samples were especially prone to misclassification. Japanese Brazilians were easily recognizable as being from Asian descent but many were classified as Hispanic, most likely because the Hispanic group represented in the forensic data bank is of Mexican origin with a strong indigenous component (Urbanova et al., 2014). In addition, the correct classification of sex was lower than expected garnering a success rate of 60-71%. The authors cite Ross et al. (2004) noting that Latin American population groups have complex ancestral backgrounds and contain various parental populations across the globe. Further Dudzik and Jantz (2016) observed that FORDISC routinely misclassified Hispanic individuals into Asian categories within FORDISC. The authors suggest that shared ancestry among Japanese and Native Americans could contribute to the misclassification of Hispanic individuals as Japanese. Further they postulate that the Japanese, like the Hispanic groups, are a hybrid population themselves and the overlap of traits between the two groups may be a relic of admixture. Forensic anthropologists observe biological cues of unknown skeletal remains in an attempt to interpret the evolutionary histories of modern people. Studies like these demonstrate the difficulties associated with the application of tools and methods, such as FORDISC and visual morphological inspection, to correctly classify individuals.

Finally, a review of the application of FORDISC wouldn’t be complete without the discussion of what is perhaps considered one of the most controversial studies conducted on the use of FORDISC by Williams et al. in 2005 (see Hubbe and Neves/Williams and Armelagoss, 2007 and Freid et al., 2005). Williams and colleagues
(2005) attempted to classify ancient Nubian crania using the Howell's dataset in FORDISC 2.0. Results produced poor results with ten crania utilized for the study were not classifiable and eight were incorrectly classified. When the FDB was used as a reference population, 12 crania were identified as white, 11 as black, three as Japanese, one as Hispanic, and one as Native American. These results led the authors to conclude that FORDISC is “fundamentally flawed,” and that statistics cannot adequately address the vast amount of variation within population groups. Moreover, they conclude that the idea of distinct lines existing between groups is based on social rather than biological realities. Although this critique of the ability to classify population affinities is reasonable, the Williams et al. (2005) study, not FORDISC, is considered by many to be unsound (Fried et al., 2005; Ousley et al., 2009; Hubbe and Neves, 2007). Critics of the study claim the poor results obtained by Williams et al. (2005) are because they employed only 12 variables to classify the crania (Hubbe and Neves, 2007). Ousley et al. (2009) critique the study with the fact that ten of the Nubian crania showed typicality probability statistics that are too low (P < 0.05) to be assigned with confidence. The typicality probability statistic informs analysts about the relative similarity of the unknown individual as compared to those within the reference group. This is important because of the program's use of discriminant function analysis. Discriminant function analysis will force a classification for any skull entered into the program whether it be a different species or a soccer ball (Fried et al., 2005; Ousley et al., 2007). Thus, low typicality probability statistics indicate outliers or poor measurement data (Maindonald and Braun, 2003; Hair et al., 2006; Tabachnick and Fidell, 2007). Despite
disagreements on the interpretation of the data in the above studies multivariate analysis of human variation can be useful (Ousley et al., 2009) because using multiple measurements of crania provide better overall assessment. Many studies (Ousley and Jantz, 2002; Spradley, 2006; Spradley et al., 2008a, 2008b; Ross et al., 2004, 2005; Slice and Ross, 2004; Ousley and Billeck, 2001; Ousley et al., 2005) have shown success in using the program to discriminate American whites, Africans, Hispanics, and Native Americans.

To address the controversy surrounding the utility of FORDISC when an unknown individual’s source population is not represented in the database, Elliott and Collard (2009) designed a study to understand the effect of including and excluding the individual’s source population. This was to observe the impact of the analysis when the individual's source population was present or absent. To accomplish this, metric data from six iterations of 10 non-overlapping variables from a large sample in Howell's dataset (which is one of the two reference datasets used in FORDISC) was analyzed in FORDISC both with and without their source populations. The number of variables, 10 in this case, was determined by a formula provided by Jantz and Ousley (2005) for determining the number of variables that should be used in a FORDISC analysis. Non-overlapping sets of variables were used to control for the possibility that different areas of the cranium are more useful in determining ancestry than others (Harvati and Weaver, 2006). Results showed when the source population was excluded; the program's performance was based on the percentage of test specimens assigned to the most closely related population in the reference sample. Additionally, Elliott and Collard
(2009) used the posterior probability (PP > 0.5) and typicality probability (TP > 0.01) statistics recommended by the FORDISC manual to evaluate group membership.

Further, they state that in a February 2007 workshop, FORDISC’s designers suggested that posterior probabilities less than 0.8 are more likely to be incorrect than correct, so a separate analysis was conducted to reflect PP > 0.8 and TP > 0.01. When the posterior probability threshold was 0.5 and greater, 80% of the specimens were correctly classified when the source population was included in the analysis. Correct classification dropped to 24.5% when the source populations were not included in the analysis. When the posterior probability threshold was 0.8 and greater, 69.5% of the specimens were correctly classified when the source population was included in the analysis. Correct classification dropped to 12% when the source populations were not included in the analysis. Results also showed lower classification accuracies when ten measurements were used from various portions of the skull (see: Elliott and Collard, 2005 for specifics) to test whether the number of variables used in the discriminant function analysis affected the classification accuracies (see: Hubbe and Neves, 2007 and Jantz and Ousley, 2005 for debate on this). Taken together authors conclude that ancestry estimation using FORDISC is problematic (Elliott and Collard, 2009). When 56 variables were used and the source population was included in the analysis, the program classified between 69.5% (PP > 0.8) and 80% (PP >0.5) of the specimens correctly. Given these results, and that the other analyses performed fared much worse, suggests that FORDISC can be useful when the unidentified individual is largely complete and belongs to one of the source populations in the database.
All of this information taken together, the fundamental problem with FORDISC lies in the inability for the program to correctly classify individuals that have phenotypes not represented within the population samples in the database. A contributing factor that underlies the aforementioned problems encountered with FORDISC is the sample population itself. Even though the database contains the largest population of known modern Americans and other groups (a marked improvement over the samples provided by Giles and Elliot), the program is not likely to accurately categorize unknown individuals whose ancestral groups are not represented in the database (Jantz and Ousley 2013, Freid et al., 2005; Elliott and Collard, 2009). Currently, the database is comprised of individuals that are classified as black and white Americans, Chinese, Japanese, Guatemalan, Hispanic, Native American, and Vietnamese. These groups are not equally represented, nor do they each contain equal representation of males and females. Therefore, it is up to the user to assess whether the results are realistic or spurious. Table 4 shows the current population of forensic cases in the FORDISC database (FORDISC Help File Version 1.36, obtained July, 2016). These numbers do not reflect the Hamann-Todd or Terry collections that are also available for use.

Additionally, some of the 19th century groups from the Hamann-Todd and Terry collections are only represented by only a few samples. Taken together, the populations represented in FORDISC are not robust enough to address the variation that exists within each group. The analyses of unknown individuals that do not fit a typical phenotype are unlikely to yield a correct classification from FORDISC. Furthermore, the database is not equipped to analyze individuals of recently mixed
Table 4. FORDISC Forensic Population

<table>
<thead>
<tr>
<th>Ancestry</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>American White</td>
<td>518</td>
<td>340</td>
<td>858</td>
</tr>
<tr>
<td>American Black</td>
<td>156</td>
<td>96</td>
<td>252</td>
</tr>
<tr>
<td>American Indian</td>
<td>59</td>
<td>32</td>
<td>91</td>
</tr>
<tr>
<td>Hispanic</td>
<td>227</td>
<td>62</td>
<td>289</td>
</tr>
<tr>
<td>Chinese</td>
<td>79</td>
<td>0</td>
<td>79</td>
</tr>
<tr>
<td>Guatemalan</td>
<td>83</td>
<td>0</td>
<td>83</td>
</tr>
<tr>
<td>Japanese</td>
<td>84</td>
<td>58</td>
<td>142</td>
</tr>
<tr>
<td>Vietnamese</td>
<td>51</td>
<td>0</td>
<td>51</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,257</td>
<td>588</td>
<td>1,845</td>
</tr>
</tbody>
</table>

ancestry and therefore may not represent the growing number of people in the United States who identify with multiple races (Urbanova et al., 2014). Currently, there are no individuals in the database that are listed as having mixed ancestry of any kind. This is fundamentally related to how race and ancestry are perceived in American culture and within the medicolegal system, including how the ancestries of forensic cases are recorded in the database. Recall the United States census data where in 2010, nine million people identify as being members of two or more races. However, missing persons reports and law enforcement are interested in the perceived race of the individual, not necessarily their ancestral background, which, consequently, is what FORDISC is designed identify. Thus, individuals with admixed ancestral backgrounds may not self-report that information upon body donation to the Forensic Anthropology Center at the University of Tennessee or in the instance forensic cases, the reporting party may not disclose that information. The consequence is that individuals with

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4 Taken from the FORDISC Help File, July 2016
admixed ancestries and/or atypical phenotypes may not classify correctly in FORDISC; rather the program will force the individual into a group that represents the best fit based on ancestral features that may not correlate with racial categories.

Further, the program allows the user to select which sample groups to compare against the unknown and if those selections are inappropriate, the classification will yield an assessment of ancestry that will provide low probability and typicality statistics. It is currently unknown how accurately forensic anthropologists are at selecting population groups for analysis. Also important is that the program is not designed to account for user error or the misapplication of the probability and typicality statistics provided with the assessment. The FORDISC program is available to anyone for purchase from the University of Tennessee, but formal training is not required to use the program. Without proper training in FORDISC, misinterpretation of the results is likely. Notwithstanding these limitations, FORDISC also includes a number of unknown samples from a collection of modern forensic cases housed at the University of Tennessee. The program uses these unknown individuals in calculations when a researcher or forensic professional enters information about an individual. Finally, anthropologists are encouraged to submit measurements from research projects and forensic cases regardless without knowledge of how the measurements were taken and if they are accurate.

Ancestry estimation methods are tools to help afford identifications. One of the underlying assumptions is that some ancestral characteristics can be useful for population assignment, yet anthropologists understand that this assumption is
commonly violated, making it imperative that the forensic anthropologist not only apply the techniques correctly but also interpret the results carefully. In many cases the results are ambiguous and ancestry should not be reported. Variation within population groups is extensive and analytical methods are often unable to isolate or identify population level variation (observed by Lewontin, 1972). Further, none of the methods currently available are equipped to reliably estimate the ancestry of mixed population groups or recently admixed individuals (Hughes et al., 2011).

First, there is so much variation within population groups that current methods for placing individuals into discrete ancestral categories cannot manage an individual with an atypical phenotype (Hefner, 2009). Second, recently admixed individuals display an assortment and blending of skeletal traits that have traditionally been reported to occur more frequently in some groups more than in others (see: Rhine, 1990; Gill, 1998; Gill et al., 1988). The blending of skeletal traits in mixed populations and in recently admixed individuals further confounds the process of ancestry estimation for the forensic anthropologist and there is no way to predict which traits will be expressed or will be more pronounced.

SWGANTH (2013) provides best practices for ancestry estimation of skeletal remains. The document outlines the following recommends for when estimating ancestry from skeletal remains:

• Ancestry assessment should be made independently of suspected or presumptive identifications.
• Use methods based on large appropriate sex-and period-specific standards/samples with sufficient sample sizes and with objective ways of measuring and recording traits.

• Measurements and non-metric observations should always be recorded, even if samples for DNA analyses will be taken.

• Use adequate traits with appropriate statistical methods of classification. Express probability of certainty when reporting ancestry assessments, especially because ancestry assessments should never be given with 100% certainty as expressed in posterior probabilities.

• Use all appropriate and available groups for your case, but remember that the most appropriate reference samples may be unavailable for analysis.

• Know metric or non-metric trait definitions and be sure to understand how to score and record them.

• Understand the appropriate statistical methods employed in ancestry assessment and understand the interpretation of the results.

• Use terminology that is appropriate and widely accepted within the local vernacular, e.g. these remains likely represent a person who self-identified as Black during life.

• When comparing against reference groups, if the skeleton is complete and sex is unambiguous, perform a sex specific analysis, (i.e. if skeleton is clearly male, compare against male reference groups only).
Anonymized raw data should be submitted to open-access anthropological data repositories to support future research and methodological improvement.

**Stature Estimation**

Stature is the portion of the biological profile that estimates the approximate height of the deceased individual. There are many ways in which stature can be estimated, but the method employed depends on the recovered skeletal material available to the forensic anthropologist. Before the various methods are discussed, a brief description of the types of stature (living stature, forensic stature, and cadaveric stature) is warranted. Living stature is the “actual stature of a person standing in a standardized position as measured using calibrated equipment such as an anthropometer or stadiometer” (Cardoso et al., 2016; p55). Living stature varies throughout an individual’s lifetime and also at any given time of the day. People tend to be tallest in the morning after vertebral discs have decompressed after a period of rest. Over the course of the day, vertebral disks become compressed and the individual becomes slightly shorter. Over a lifetime, people gradually become shorter as a result of years of joint degeneration (Cardoso et al., 2016). Forensic stature is the recorded height of an individual on government documents such as identification cards, passports, driver’s licenses, etc. (Ousley, 1995). These records vary depending on whether the stature was measured or if it was self-reported. Cadaveric stature is the length of the cadaver taken prior to autopsy (Cardoso et al., 2016). Cadaveric stature is
measured while the individual is lying in the supine position and is subjected to error because compression of joints normally present in a standing position is not occurring (Cardoso et al., 2016). Cadaveric stature is used by medical examiners with a fleshed body and is not used for skeletal remains.

Law enforcement investigators obtain information about a missing persons living stature from family members, friends, or from driver’s licenses and medical records. However, this information may not always be accurate as family members and friends may not accurately report the height of the missing. Additionally, people (particularly men), tend to overestimate their height on driver’s licenses (Willey and Falsetti, 1991) and stature tends to decrease with increasing age (Giles and Hutchenson, 1991). There are also instances where major discrepancies between reported stature and living stature have been documented. In one case at the University of Tennessee, Ousley (1995) found that one individual, a 24-year-old male, was eight inches taller than what was reported on his driver’s license. Discrepancies, as in this case, could also be a result of typos or data entry errors.

Forensic anthropologists estimate living stature by applying regression formulae to the direct measurements of long bone lengths. This method is used because of the strong correlation between living stature and lower limb bone measurements (Trotter and Gleser, 1952; 1958; Wilson et al., 2010). Using regression analysis, early stature formulae were derived from the Terry Collection, as well as remains from WWII and the Korean War (Trotter and Gleser, 1952; Trotter, 1970), but limited to males only. Recent regression formulas were developed from modern skeletal materials in the Forensic
Data Bank at the University of Tennessee (Ousley, 1995). These formulae were developed for white and black Americans only, although new formulae are currently being developed for Asian individuals (Jeong, 2014). In addition to long bone measurements, the Fully method, which sums skeletal element heights, can be used when all skeletal elements contributing to stature are present and complete (Fully, 1956). However, the revised Fully technique for anatomical stature estimation is advised (Raxter et al., 2006). The revised Fully method measures each bone that contributes to stature and applies calculations for soft tissue corrections to obtain stature estimations. This method, like the Fully (1956) methods, requires that all skeletal elements contributing to stature are recovered and in good condition, however, statistics have been developed to account for missing data (Auerbach, 2011).

Although, typically accurate, but not precise (refer to the discussion on accuracy versus precision), the usefulness of stature estimation for the identification of unidentified individuals is currently unknown. Stature estimations include wide prediction intervals that typically encompass several inches on each side of the estimate to ensure accuracy; therefore the living stature of unidentified individual is likely to fall within this range. Despite efforts to ensure accuracy, the height of an unidentified person is not a unique identifying piece of information. Most Americans fall within an average range of height thus, stature is not particularly useful unless the missing individual occupies an extreme end of the height continuum, (e.g., the person is very short or very tall). To further prove this, Steadman et al. (2006) calculated the likelihood ratio for stature using the length of the femur. Since the majority of individuals in the
population at large have little variance in stature, the likelihood ratios produced for stature are not very informative (Steadman et al., 2006). Nevertheless, stature estimation can be used to exclude a potential identification if the estimate of the unknown individual is considerably different than the height of the missing person.

SWGANTH (2012) provides best practices for stature estimation of skeletal remains. The document outlines the following recommends for when estimating stature from skeletal remains:

• If complete remains are present, either the anatomical or regression methods should be used. The measurement guidelines for the chosen technique should be followed. When complete skeletons or whole limb bones are not available or external factors require altering best practices, other means of estimating stature may be employed including the use of fragmentary limb bones and non-limb bones. The precision and accuracy of these alternative methods may be less than those approaches presented in the previous section. Additional adjustments to all methods should also be considered where appropriate.

Utility of Forensic Methods

The previous sections outline problems associated with the standards of evidence and difficulties encountered in the generation of the biological profile. Overall, the biological profile provides information about the decedent that can be used to help in an investigation, however, elements of the biological profile may not be sufficiently
accurate or precise to lead to investigators to a presumptive identification. The biological sex of an unknown provides investigators with male or female label, but it does little to provide specific information about the individual. The approximate age at death estimations for adult individuals can be too wide-ranging to narrow the potential list of matches, because methods for adult age estimation are based on degenerative processes that vary among individuals. Estimated age ranges can vary as much as 20+ years, rendering the estimation accurate, but not precise. Ancestry estimation can be informative if it is biologically correct and matches the social/cultural label the individual ascribed to in life. Even if correct on these two fronts, ancestry estimation is not informative in relatively homogenous communities. Examples include rural areas of the United States such as Gary, Indiana where the majority of residents identify as African American or rural Iowa where the population primarily identifies as white (Konigsberg et al., 2009). Additionally, ancestry estimation may not be informative when identifying victims of genocide in mass graves because the deceased are typically targeted and killed because of a shared ancestral background. Finally, stature estimation, although usually accurate within the calculated range, is uninformative unless the individual occupies the extreme edges of the normal range of human height.

To address the problem of the utility of the biological profile, Konigsberg et al. (2009) make use of likelihood ratios and informed priors to determine the evidentiary value of the sex and ancestry components biological profile. In their article, sex and ancestry from an active forensic case are used to illustrate an example. The article details the relative ease of making a correct estimation of sex in a forensic case, but
that sex estimation is relatively uninformative to make an identification since the maximum likelihood for sex is two. Ancestry estimation in this case proved to be more difficult as the FORDISC 2.0 analysis of the skull indicated that the unknown was an Easter Islander. The skeletal remains were found in rural Iowa where the census data shows that 93.82% of the population of Iowa identifies racially as white. Having prior knowledge that the probability of an Easter Islander in this racially homogenous area is low, the anthropologist reported the race of the unknown as white. Interestingly, if this individual were found in Hawaii, where a high proportion of Pacific Islanders reside, the original estimation of Easter Islander would be acceptable. Further, if this individual were found in Gary, Indiana, where the population is primarily black, the informed prior coupled with the metric analysis would lead the anthropologist to conclude that this individual is black. These results show the usefulness of informed priors in forensic analysis (Konigsberg et al., 2009). Further, the study found that if an anthropologist works in a relatively homogenous population, the ancestry of the individual likely matches the demography of the region and therefore, contributes minimal information to a potential identification. For anthropologists in heterogeneous areas, such as large cities like New York, Houston, or Tucson, ancestry estimation can be a valuable component of the biological profile assuming the anthropologist is adept in assessing ancestry in heterogeneous populations (Konigsberg et al., 2009) and if the phenotype of the unknown mimics the reference population from which the methods were developed.
Chapter Summary

The information presented in this background chapter highlights the role of the forensic anthropologist in the medicolegal system. As a part of the medicolegal system, forensic anthropologists are required to perform duties to the rigorous standards and expectations set by the courts. This chapter outlined the four components of the biological profile evaluated by this research and discussed their applications and theory behind the methods. The next chapter further details theory surrounding the estimation of biological ancestry and how it relates to social and cultural understanding of race.
CHAPTER THREE

BACKGROUND

Race and Ancestry

This chapter discusses the ongoing debate within anthropology about human biological variation. A large discussion within the field of forensic anthropology involves the differences and the use of the terms ancestry and race and how scientists and the lay public alike interpret their meanings.

In the United States, forensic anthropologists and law enforcement officials face a fundamental barrier when it comes to racial identifications of unknown individuals. The disconnect lies in perceptions and expectations: law enforcement asks for a racial classification, more specifically someone’s skin color or what they looked like, whereas forensic anthropologists attempt to provide an assessment of biological ancestry. Ancestry estimation assumes that skeletal traits reflect a biological reality (ancestry) and that these observed traits can be translated into a corresponding social category (race). The topic of race permeates American culture, yet few people understand the biology behind our differences, or similarities for that matter.

To unpack these matters, an abbreviated history of racial classification and its evolution within physical anthropology will be discussed first. Second, ancestry and race will be defined in light of the history discussed. Third, the role of race and ancestry in forensic casework will be explored and finally, the complications associated with
racial self-identity and the assignment of racial categories to skeletal materials in forensic casework will be examined.

**History of Racial Classification in Forensic Anthropology**

The initial framework of the concept of race can be attributed to the European worldview in the 18\textsuperscript{th} century (Brace, 2005). Racial classification in the 18\textsuperscript{th} century was centered on the ability to visually assess physical characteristics of our species championed by Carlous Linnaeus (1707-1778), a botanist who published *Systema Naturae* in 1735 (Brace, 2005). *Systema Naturae* outlined a system to arrange and categorize plants and animals based on physical features. He classified humans into four geographical varieties: *Homo sapiens europaeus, Homo sapiens asiaticus, Homo sapiens americanus, and Homo sapiens afer* (Linnaeus, 1759).

The labels assigned to all living organisms in *Systema Naturae* were also designed to fit with a hierarchical structure known as the Great Chain of Being that categorized all living beings and inorganic materials from the top, God, down (Lovejoy, 1936). The hierarchical nature of the Great Chain of Being was challenged by late 18\textsuperscript{th} century scholars but still influenced Western views of the world (Brace, 2005). Examples of this influence can be seen in the scientists of the mid to late 18\textsuperscript{th} century. Peiter Camper (1722-1789) was one such scientist who employed a method to hierarchically categorize humans. He developed the “facial angle,” a measurement of the angle defining the facial profile by which he classified individuals with steep facial
profiles into works of art and those with angled facial profiles among the animals (Camper, 1791; Meijer, 1997).

Meanwhile, Johann Friedrich Blumenbach (1752-1840) believed that the human form was influenced by a host of environmental factors that eventually allowed man to digress from the ideal form. For Blumenbach, the ideal form was the people from Mount Caucasus, whom he called Caucasians. Despite ascribing to the idea that man degenerated from superior (white) to inferior forms, Blumenbach was one of the first to acknowledge that people resembled their ancestors and that people in different geographical areas had different visual characteristics (Brace, 1997).

In America, Samuel Morton (1799-1851), a physician and anatomist was also a pioneer in anthropology amassing a large collection of human crania from which he studied the races of man (Brace, 2005). Morton in his 1839 work titled, *Crania Americana*, identified races that are unrelated from one another and thus categorically distinct. He used his measurements to identify racial types and also filled skulls with lead shot to discover if cranial volume differed between the races and, if so, how they differed. His results showed Caucasians had the largest cranial capacity, followed by the Malays, the Negro group, and lastly Native Americans. Gould, in his book, *The Mismeasure of Man* (1981) criticized Morton’s work as inherently biased, as he believed that Morton skewed his data to fit his views of human variation. Allegations by Gould ranged from the idea that Morton selectively reported his data, manipulated sample compositions, made analytical errors, and mismeasured skulls. However, Lewis et al.
(2011) reanalyzed Morton’s data and concluded that he did not manipulate his data and that Gould’s criticisms are unfounded.

In the 20th century Ales Hrdlička (1869-1943) and Franz Boas (1858-1942) emerged as two important figures in American Anthropology (Brace, 2005; Caspari, 2009). At the time, physical anthropology in the United States was regarded as racial studies, and Hrdlička, a Czech immigrant, acknowledged racialized foundation of European anthropology (Caspari, 2009). In contrast, the German-born Boas practiced the four-field approach to anthropology and over the course of his career challenged the validity of human types (Caspari, 2009). He was interested in metric studies of human variation and compiled data to document the human form. His studies documenting the cranial morphology of immigrant descendants (see: Boas, 1910; 1912; 1940) began to question the idea that races are types, instead showing that the skull is subject to plasticity. Debate surrounding the validity of his findings has surfaced (see: Fisher and Gray, 1937; Morant and Samson, 1936; Sparks and Jantz, 2002; Gravlee et al., 2003). Regardless, Boas’s work is generally accepted in the sciences (Sparks and Jantz, 2002).

Also during this time, Earnest Hooton (1887-1954) emerged as an influential figure in anthropology. He has been credited as the father of physical anthropology in America (Shapiro, 1981) and believed in the concept of pure races. For Hooton, the variations observed among the races could be explained by the inbreeding of the pure races, which he called secondary races (Caspari, 2009). In all, race in 20th century America referred to geographic patterning of human variation and assumptions of
essentialism to explain those variations (Caspari, 2009). As such, races were considered types, or unchanging natural categories. Despite the work of Boas demonstrating the nonconcordance of features, racial typology continued. Caspari (2009) offers an explanation of essentialism, the idea every being has a fixed immutable form, that allowed typological thinking to persist despite scientific evidence showing otherwise.

More recently, the debate around race has changed due to the continuance of scientific studies of human variation from blood serum analysis, morphological and metric studies of the human skeleton, and DNA research. A number of researchers and scholars have contended that races do not exist, rather race is a cultural construction devoid of biological reality (Armelagos, 1995; Armelagos et al., 1982; Blakey, 1987; Brace, 1982, 2005; Brace et al., 1993; Goodman, 1997a, b; Goodman and Armelagos, 1997; Hahn and Stroup, 1994; Livingstone, 1962; Lock 1993; Marks, 1994, 1995, 1998; Montagu, 1942, 1978; and Mukhopadhyay and Moses, 1997). Further, studies of neutral genetic variation have supported Lewonton’s results (Nei and Roychoudhury, 1982; Barbujani et al., 1997; Jorde et al, 2000; Rosenberg et al, 2002). Meanwhile, other scholars argue for its continued use (Sarich and Miele, 2004). The argument against race is partly based on Lewonton’s publication of The Apportionment of Human Diversity in 1972 where he demonstrated that race accounted for 6% of all human variation (Smay and Armelagos, 2000). From here, Livingstone in 1962 famously stated that races didn’t exist; rather there are only clines.
Regardless of the position, assumptions about race persist in anthropological work today (Caspari, 2009). These assumptions include but are not limited to, statistical classification of individuals into a pre-set number of population groups, assumptions of group membership based on genetic features, and the logical disconnect that exists among researchers that argue for the non-existence of human races all the while discussing the genetic evolution of races (Brown and Armelagos, 2001). In addition, inconsistent terminology used to describe group membership confounds understandings of complex relationships between biological variation and the social/cultural understandings of race.

**Ancestry and Race**

The terms race and ancestry have been defined in various ways. The following section outlines some of the many definitions of race and ancestry employed in the literature.

**Ancestry**

Ancestry can be described geographically. Many scholars refer to ancestry as the biological or genetic makeup of individuals that can be used to trace geographic or continental origins (Royal and Dunston, 2004; Molnar, 1992). Similarly, Garn (1965)

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5 Race is sometimes used in place of the term ancestry. In this subsection on ancestry, references to race are original to the published scientific studies cited and are meant to denote ancestry.

6 Ancestry is also referred to as biological race or geographical race.
describes what he calls geographic race by the subdivision of humans into continental groupings such as Europeans, Asians, and Africans. He explains these groupings can be further subdivided into subcontinental groupings such as Southeast Asians, and East Asians. These definitions demonstrate that an individual’s ancestry is influenced by, but not limited to, a combination of genetic drift, gene flow, migrations, microevolution and environmental pressures (Konigsberg et al., 2009; Relethford, 2009), examples being climate or mating practices (Cartmill, 1998). It is assumed that individuals cluster into broad geographical or continental groups because of shared genetic history and environment, and therefore possess similar physical traits and characteristics.

Studies conducted by Lewonton (1972) and Livingstone (1962, 1964) were among the first to challenge the idea that population groups were genetically distinct, finding that population groupings had vast amounts of genetic diversity within them. Livingstone famously stated, “there are no races, there are only clines” (1964:47). These words and his scathing review of the race concept in Ashley Montagu’s, The Concept of Race, ignited a firestorm of debate surrounding the reality of race. In his landmark publication, Livingstone recognized that morphological traits do not support the distinction of races. In fact, Livingstone remarks:

If one genetic character is used, it is possible to divide a species into subspecies according to the variation in this character. If two characters are used, it may still be possible, but there will be some “problem populations,” which, if you are an anthropologist, will be labeled composite or mixed. As the number of characters increases it becomes more nearly impossible to determine what the “actual races are” (Livingstone, 1964:47-48)
Thus the use of physical traits to distinguish racial groups is inherently flawed because genetic and morphological variation is continuous and overlapping \textit{within} and \textit{between} populations (Livingstone, 1964; Lewonton, 1972). In his innovative study, Lewonton (1972) analyzed blood serum proteins and red blood cell enzyme variants. His results support the assertions made by Livingstone and indicate that racial classification accounts for only 6.3% of total genetic diversity, population differences account for only 8.3%, while individual differences account for the remaining 85.4%. This study was the first of its kind to determine the extent that racial characteristics account for human genetic variation and it proved that genetic traits are nonconcordant. His conclusions clearly show that genetic differences between individuals have little to do with racial or ethnic boundaries.

Today, population geneticists routinely utilize genetic data to identify ancestral groupings worldwide because genetic data can help reconstruct population histories, analyze within and between group differences, and calculate biological distance (Long et al., 2009; Hunley et al., 2009; Serre and Paabo, 2004; Manica et al., 2005; Prugnolle et al., 2005; Ramachandran et al., 2005; Handley et al., 2007). Through the exploration of genetic information of various human groups, researchers have found that geographically and socially distinct populations have more genetic variation within, rather than between groups. Thus, genetic studies provide the most recent evidence supporting the nonconcordance of biological traits (see: Serre and Paabo, 2004; Barbujani and Bell, 2006). These studies confirm findings by Lewonton indicating that the majority of genetic variation exists within population groups rather than between.
Therefore, the majority of human genetic variation is shared among all humans with little variation between supposed racially defined groups.

Relethford (1994; 2002) demonstrated that the apportionment of global human genetic diversity is not discrete. He found that craniometric variation and genetic diversity follow patterns of neutral traits (traits not affected by selection), where there is more variation within than between populations. Interestingly, his 2002 study results show that skin color (often used by law enforcement and the general public to infer race) follows the opposite trend of craniometrics (what forensic anthropologists use to estimate ancestry) and genetics, as skin color operates under natural selection and thus, is not neutral (Relethford 2002). The results of his craniometric analysis show that approximately 13% of the diversity among the samples is between regions, 6% of diversity is between local populations within regions, and 81% of the variation exists within local populations. These results mirror blood protein polymorphism studies (Latter, 1980; Ryman et al., 1983) and DNA polymorphism studies (Barbujani et al., 1997; Jorde et al., 2000) showing that approximately 85% of genetic diversity exists within populations (Relethford, 2002). Further, Relethford’s (2002) results indicate that skin color, shows more variation between populations than within. Although forensic anthropologists cannot identify skin color, skeletal analysis of ancestry is used to infer skin color to assist law enforcement with the identification of unknown individuals. The inference of skin color based on skeletal traits commonly associated with racial groups is contested in the literature. Thus, Relethford (2002) implies that various traits, such as skin color, used by law enforcement and the general public to distinguish races, are not
supported by craniometric and genetic analysis. Therefore, morphological metric analyses utilized by forensic anthropologists to estimate ancestry for the purpose of providing social race categories for law enforcement is ambiguous, at best.

However, this is not to say that geographic patterning doesn’t exist. To the contrary, Relethford (1997; 2009), shows that there is geographic patterning to skin color and to craniometrics. In his 1997 article, Relethford demonstrated that human skin color is darker in the southern hemisphere than in the northern hemisphere, corresponding to higher UV radiation in the southern hemisphere as opposed to lower UV radiation levels in the northern hemisphere. Relethford (2009) showed that there is an association with craniometric variation and geography indicating that populations further apart from one another will be less similar than to geographically closer populations. However, there are no breaks or distinct cut off points that separate geographical groupings, and overlap exists between the six groups used in the analysis (Relethford, 2009). However, Relethford (2009) cautions that the population groupings analyzed for his study, and groupings analyzed in other studies as well, are subjective and defined by the researcher. In other words, these arbitrary groupings do not reflect biological realities or actual races. To illustrate the point in a different way, most human populations today are the product of admixed genes from many different groups (Shipman, 1994). Shipman (1994) further explains that ethnic groupings of people, such as African Americans, Asian Americans, and Native Americans, are genetically mixed and thus, are not biological races.
Races have been synonymous with types and often considered to be natural categories, reflecting typological thinking (Caspari, 2009). In human biology, race refers to a culturally constructed classification system with roots in Western colonialism by which individuals are typically categorized according to physical appearance (Montagu, 1942; Brace, 2005; Smedley and Smedley, 2012). Unlike biological ancestry, race is considered to be a “culturally structured, systematic way of looking at, perceiving, and interpreting” reality (Smedley 2007, p. 18). Komar and Grivas (2008) note that “race and ethnicity are flexible social constructs in which an individual’s membership within a specific group can be self-proclaimed or perceived (p. 229). These definitions reflect the American worldview that human populations can be divided based on physical characteristics believed to be biologically significant (Edgar, 2009; Smedley, 2007; Smedley and Smedley, 2012; Keita and Kittles, 1997). Relethford, (2009) discusses the underlying biological significance of physical traits explaining that some physical characteristics are geographically structured and that race can be defined as a “culturally constructed label that crudely and imprecisely describes real variation” (Relethford, 2009).

Elements of physical appearance, such as skin color, hair color, hair type, and facial features are often understood by society to be objective biological attributes upon which social constructions are built (Smedley 1998; Wade, 1993; Wade 2002; Relethford, 2009; Albanese and Saunders, 2007). However, Smedley and Smedley (2012) draw attention to the fact that being a member of a certain racial category does
not require having all or any of the physical attributes commonly associated with that category. An example rests within the African American community. Smedley and Smedley (2012) remind us that those who identify as African American are perhaps among the most heterogeneous population in the world. African Americans range from fair-skinned, blond-haired, and blue-eyed to dark brown skinned, dark haired and brown-eyed, and combinations in between.

Tishkoff and Kidd (2004) state that one drawback with using race as an identifier is the lack of a clear definition of race. Many people associate race with skin color or other physical characteristics. However, morphology and skin color are poor indicators of race because they are the result of adaptations subject to convergent evolution (Tishkoff and Kidd, 2004; Relethford, 1997; 2000; 2009). Relethford (1997; 2009) further explains that the distribution of human skin color is continuous and has an atypical pattern in within human groups providing evidence that human skin color, although geographically patterned, does not differentiate human races. In other words, skin color demonstrates patterns of clinal variation. Further, culture, language, and religion are also poor indicators of race. An example is the use of the term Hispanic to describe a diverse population of individuals with varying nationalities, identities, cultural traditions, and biological origins that include European, Native American and African ancestries in various amalgamations (Birkby et al., 2008; Lisker et al, 1996). Overall, the vast degree of variation within and between population groups problematizes the lay concepts of racial divisions. Forensic anthropologists must deal with the variations of the phenotypic expression of genetic traits as well as the translation of that information
to the public whom may not understand the nuances of racial identity and biological ancestry.

Taken together, ancestry is how human biological variation is understood in terms of geographic dispersion of physical and genetic traits. Race, is a socially constructed understanding of the physical features of human populations that are associated with geographic and biological ancestry.

Ambiguous Terminology

A confounding factor in forensic ancestry estimation is that the terms race and ancestry are used interchangeably among forensic anthropologists and law enforcement. It has become standard practice for forensic anthropologists to use the term ancestry instead of the term race (Albanese and Saunders, 2006; Ousley et al., 2009). Introductory level forensic anthropology textbooks try to explain this transition to aspiring students by explaining, “race engenders too many negative connotations” (Byers, 2005:11). Presumably these negative connotations stem from the deep-rooted history of racism in the United States, for which anthropological practice had also contributed (Caspari, 2003). However, this explanation is simplistic and undermines the scientific progress made to understand human biological variation resulting from complex population histories. Further, anthropologists prefer the term ancestry because that is what is being assessed; cultural race labels cannot be estimated from skeletal remains.
There are many examples of the interchangeable use of typological terminology throughout scientific literature and through time. Rhine (1990), a reference for typological ancestry estimation, refers to “racial groups” as “American Caucasoid,” “Southwestern Mongoloid,” and “American Black.” Byers (2005), in an introductory forensic anthropology textbook, describes populations as “ancestral groups” and identifies them as “Black,” “White,” and “Asian.” In France and Horn’s (1988) introductory textbooks, *A Lab Manual and Workbook for Physical Anthropology*, a change in the attitude between taxonomic descriptions over many editions can be found. In the first edition, the terms “Negroid,” “Caucasoid,” and “Mongoloid” are used to classify unknown individuals, but by the 4th edition (France, 2001) uses the terms “African,” “European,” and “(East) Asian.” The revised 4th edition also shows the adjustment of the term “race” to “ancestry” (compare p. 30 of the first edition to p. 123 of the 4th). Since the terms Caucasoid, Mongoloid, Negroid are antiquated terms, it is most likely the reason for the change in France’s 2001 edition. Yet, as of 2005, Dr. William Bass’ quintessential osteological field manual still retains the outdated typological terminology and it was only in 2013 that the Joint POW MIA Accounting Command (now the Defense POW/MIA Accounting Agency) removed the terms from practice instead now using European, Asian, and African (DPAA SOP 3.4, 2015).

It is important for the anthropological community to recognize inconsistent use of the terms race and ancestry in scientific literature and in practice because loose terminology confounds further already complicated topics. The distinctions outlined in this section are not just semantic, as they show little agreement in the scientific
community about the definitions of race and ancestry, and even less consensus about how to label groups. The consequences of these misunderstandings vary in degree from simple terminology to key breakdowns in communication between forensic professionals and the communities they serve.

In sum, ancestry refers to the biological or genetic makeup of individuals that can be used to trace geographic or continental origins. Race is a socially constructed classification system primarily based on visible physical features. The American Anthropological Association (AAA) provided a statement on race in 1998 that they believe outlines the general consensus and scholarly positions among the majority of anthropologists. In this statement, they contend, “human populations are not unambiguous, clearly demarcated, biologically distinct groups” and that race is an ideology of human differences that perpetuates the myth of human dissimilarities. The forensic anthropological application of methods and use of tools such as FORDISC to identify the ancestral background of unknown skeletal remains for the purpose of assigning a social race category is not in opposition to the AAA statement. Rather, the practice is an attempt to provide vital information to law enforcement though the use of socially understood terms to help identify unknown individuals.

Ancestry and Race in Forensic Anthropology

Ancestry assessment is considered the most controversial component of the biological profile (Albanese and Saunders, 2007). If studies show the non-existence of

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7 The AAA statement was prepared by a committee of representative American anthropologists and does not reflect a consensus of all members of the AAA.
human races, why do anthropologists continue to include ancestral information in reports? The answer partially lies in expectations. Racial information is useful for law enforcement since physical descriptions of perpetrators, victims, and missing persons help guide investigations. Forensic anthropologists are unable to detect racial features such as skin color, hair color, hair type, or other such characteristics from skeletal materials. It cannot be emphasized enough that forensic anthropologists can only estimate ancestry to infer race, and not race itself (Konigsberg et al., 2009). This is of little consequence to law enforcement, as they are products of modern racialized societies and rely on racial descriptions such as skin color. The lay public generally uses visual characteristics associated with races to describe missing loved ones to law enforcement. Thus, forensic anthropologists must operate under the assumption that morphology can infer geographic or continental origin; and therefore race.

Although many forensic anthropologists acknowledge that race and ancestry are not the same (Brace 1995; Kennedy, 1995), forensic anthropologists feel obligated to estimate the ancestry of unknown individuals (Sauer 1992; Kennedy 1995) and even have felt that failure to do so would be regarded as neglect of responsibilities or hindrance of an investigation (Sauer, 1992; Gill, 1998; France, 2001; Brace, 1995; Kennedy, 1995). In essence, forensic anthropologists “play their game” (Kennedy, 1995) and can be accused of perpetuating the myth of races. As discussed earlier, forensic anthropologists use ancestry to theoretically infer social race through the identification of visible physical features assumed to have biological significance (Albanese and Saunders, 2007). This practice may be successful but also may result in
misclassifications, as socially prescribed race does not always match the anthropologist’s assessment of ancestry. As a result, victims may go unidentified and interested parties consequently may be deprived of information. Although error rates associated with ancestry estimation to infer social race in casework are unknown (Hughes et al., 2011), the methods are perceived by forensic anthropologists to work well enough to justify their continued use (Sauer, 1992). This argument is tautological because there is no way to know if unidentified individuals remain unidentified because the assigned social race category is incorrect.

Sauer (1992) argues that the reason forensic anthropologists are so “good at estimating race” is because there is concordance between cranial morphology and American black and white social race categories. Yet, it remains unclear how well cranial morphology corresponds with individuals that have an atypical phenotype, non-black and non-white racial categories, or with admixed populations or recently mixed individuals. This concern is important because the United States is far more diverse than just black and white individuals. The 2010 US census reported an increase in the number of individuals identifying as non-white and non-black. Specifically, 14.7 million individuals identified as Asian and 50.5 million people identified as Hispanic. The Hispanic population constituted half of all growth in the United States between 2000 and 2010 (US Census Report, 2011). Additionally, 9 million people reported more than one race and in 2012, the Pew Foundation reported that 15% of all new marriages in the US

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8 The quote pre-dates studies disputing the concordance of skin color and cranial metric and non-metric traits outlined in the previous section.
and over 7% of the 3.5 million births in the US are multiracial (Pew Research Foundation, 2012).

Despite demographic information, perceptions of race continue to drive research that reinforces culturally constructed categories. For example, population studies of genetics and craniometrics assume prior population groupings and the number of groups can be subjectively changed (Relethford, 2009). In addition, it is unclear how forensic anthropologists treat the question of admixed ancestry (e.g. someone who identifies as admixed black and white) and how anthropologists interpret and report unidentified individuals that do not conform to a standard phenotype with known ancestral traits.

**Racial Self-Identification**

Confounding the subject of ancestry and race in biological anthropology is racial self-identification. Racial self-identification can be described as how a person identifies with their lineage. Medical studies in the United States have found self-identified race/ethnicity to be a useful proxy for genetic differentiation between groups that vary in continental ancestry (Tang et al., 2005). However, a study conducted by Hahn et al. (1996) revealed that self-identification varied among participants over the study period of four years. Forty-two percent of individuals reported different ancestry self-identifications at different times, and individuals who identified with multiple ancestries were up to 3.4 times more likely to change their ancestry classification over time.
Additionally, M’Charek (2013) argues that self-identification of race is not concrete and often changes among individuals through time in response to their social environment. The complexities of social race categories and their meanings among the U.S. population are beyond the scope and expertise of the forensic anthropologist. However, it is these social race categories that the general public and law enforcement recognize as tangible pieces of information that can help discover the identity of skeletal remains. If identities continually shift, as indicated by Hahn et al. (1996) and M’Charek (2013), then clear social boundaries of race do not exist. Thus, forensic anthropological assessment of biological ancestry to infer social race categories may not align in a society where identities and perceptions of race are fluid.

The shift in the American populations perceptions of race and self-identity are not just theoretical. The changing demographics of the United States have been continually documented in the US census data. As social and cultural attitudes regarding race have changed over time, the census questions have also evolved to better document the racial composition of the United States. According to the Population Reference Bureau (PRB) “Reports on America” (Mather et al., 2011), the census questions concerning race and ancestry have changed over time to reflect social and cultural definitions and perceptions of race. Prior to the 1950s, census enumerators were responsible for identifying census participants using limited terms for racial categories. For example, in 1910, categories used to identify people included “White,” “Black,” “Mulatto,” “Chinese,” “Japanese,” “American Indian,” or “Other” (Mather et al., 2011). In 1980, the census included a separate question about Spanish/Hispanic origin but, to
date, many Hispanics do not distinguish between race and ethnicity, instead opting to choose “Some Other Race” to designate their country of origin. According to the Mather et al. (2011), 37 percent of Hispanics marked “Some Other Race,” as compared to 0.2 percent of non-Hispanics marking that category in the 2010 census. Interestingly, between the 2000 census and 2010 census, the number of Hispanics who identified as “White” increased from 48 percent to 53 percent. This change in racial identity could reflect a change in cultural self-identification after having been born or having lived in the United States for long periods of time and adopting American culture, or it could be a reflection of changes in the census instructions that stated, “For this census, Hispanic origins are not races” (Mather et al., 2011).

The 2000 census was the first to include options for people to check more than one race, and at that time 5.8 million people indicated they were more than one race. In the 2010 census, this number increased to 9 million people. Of those 9 million people, three-fourths of them identified as white in combination with another race (black, Asian, Native American, Some Other Race) with the number of people identifying as both black and white more than doubling since the 2000 census (Mather et al., 2011). Given the increase in biracial marriage in the United States, Byrd and Garwick (2006) note that social categories of race are not clearly defined.

It is evident from the population census data that the racial composition of the United States is varied and changing. The social and cultural attitudes and perceptions of race in America, as well as technical changes to the US census forms, demonstrate that racial self-identification is a product of perception fueled by culture, physical
characteristics, and changing, often confusing, terminology. There exists a fundamental disconnect between how people identify themselves, the way they choose to identify loved ones when reporting missing persons (missing persons reports, NCIS database, NamUs database), how law enforcement utilizes that information, and the forensic tools utilized to identify race based on ancestral traits. Reconciliation between self-identity and the missing persons reporting process will go a long way to ensure forensic tools such as morphological ancestry assessment and FORDISC cannot accurately reflect the current self-identified nomenclature in the U.S.

Chapter Summary

The information presented in this chapter serves to frame the discussion of biological ancestry and race around the circumstances associated with the resolution of missing persons cases in the United States. The process of victim identification has evolved over time beginning with simple physical descriptions, photographs, and fingerprints of the deceased. Today, scientific methods guide the process of victim identification and the discipline of forensic anthropology works within the medicolegal system to provide accurate descriptions of the deceased. Although, the non-existence of human races has been demonstrated through numerous studies ranging from craniometrics to genetics, social race categories persist in society. Thus, forensic anthropologists are stuck between a rock and a hard place when evaluating biological ancestry and catering to the needs of law enforcement. As such, forensic
anthropologists rely on a combination of scientific analyses, personal experiences, and contextual informed-priors to make the best ancestry estimate possible. Despite all efforts, forensic anthropologists may not correctly identify social race categories through the application of scientific methods, rendering the estimation useless. This does not mean the effort is unnecessary, rather solutions to address the fundamental disconnect between law enforcement, the missing persons reporting process, and forensic anthropological practice should be addressed. The next chapter introduces the study sample locations, while chapter five outlines the expectations that guide this research.
CHAPTER FOUR

STUDY SAMPLE LOCATIONS

This chapter describes the study sample locations selected for this research. This sample is introduced first with a demographic description the areas of New York City, Harris County, and Pima County as well as the functions and operations of the medical examiners offices.

The Offices of the Medical Examiner, New York City New York; Harris County, Texas; and Pima County, Arizona

Data is comprised of forensic anthropology reports from three urban medical examiners offices in the United States, specifically, The Office of Chief Medical Examiner, New York City (NYC OCME); The Harris County Institute of Forensic Science (HCIFS) in Houston, Texas; and the Pima County Office of the Medical Examiner (PCOME) in Tucson, Arizona. These offices were chosen because they have high skeletal caseloads and employ in-house teams of forensic anthropologists to assist with the identification of unknown human remains. No other medical examiner offices in the United States employ multiple full-time anthropologists, rather opting to utilize private consultants. Anthropologists in the offices chosen for this research routinely assist medical examiners with all aspects of skeletal identification, trauma, and postmortem interval. In addition, working within these offices allows the anthropologists access to a variety of resources and build close working relationships with local law enforcement.
and local and national agencies dedicated to the resolution of missing persons cases. The structural similarities between the offices make them ideal for comparison even though they serve different communities.

New York City, New York

Often dubbed the "big apple," New York City is the nation’s largest city with its 8,405,837 million people occupying only 302.64 square miles (U.S. Census Bureau, 2010). As such, it is also the country’s most densely populated city with 27,012.5 people occupying each square mile in the five boroughs: Manhattan, Brooklyn, The Bronx, Queens, and Staten Island that, in 1898, were joined to make up New York City. New York City’s impact on the world cannot be understated, as this large metropolitan city has had a significant economic and cultural impact on commerce, fashion, media, research, technology, education, and entertainment. It is no wonder that New York City is also home to the headquarters of the United Nations, the center for international diplomacy.

The diversity of New York’s population is a relic of the city’s prosperity and its position at the center for world commerce. In addition, New York City is the premiere location for legal immigration in the United States (U.S. Department of Homeland Security, 2013). More than 12 million European immigrants were received at Ellis Island between 1892 and 1924 (Jones, 2008). Today the city’s diversity is evidenced by its social and cultural opportunities and also by the most recent U.S. Census report.
According to the 2010 US Census Bureau, 44% of New York City’s residents identified as “white,” and 33% reported as “white alone, not Hispanic.” The difference here may indicate some level of mixed ancestry or a difference in the meaning of the term “white” (refer to the background chapter for a discussion). The census also reports 25.5% of the population identified as “black,” 28.6% identified as “Hispanic or “Latino,” 12.7% identified as “Asian,” 0.7% identified as “American Indian and Alaskan Native,” and 0.1% identified as “Native Hawaiian and other Pacific Islander.” Interestingly, only 4% of New York City’s population indicated that they were members of “two or more races.” Keep in mind those calling themselves “white” versus “white only” could account for the low number of those identifying as “two or more races.” Also according to the 2010 U.S. Census, 37% of New York City’s population is foreign born with people representing every country in the world; however, no single country or region of origin dominates. As such, New York is home to many cultural communities including, but not limited to, six Chinatowns, Little Italy, and four Koreatowns. Asian individuals number over one million in the city, the highest population of Asians of any U.S. city. Chinatown has the highest concentration of Chinese people in the western hemisphere and New York has the largest Israeli and Orthodox Jewish communities outside of Israel; half reside in Brooklyn. Moreover, there are approximately 800 languages spoken in the city attesting to the tremendous cultural diversity that permeates the city.

The city of New York also has the highest rate of homelessness in the United States. According to the Coalition for the Homeless, in November of 2014 there were a recorded 60,352 homeless people living in New York City shelters on any given night,
an increase of 64% from ten years ago. This figure includes 14,519 families with 25,640 children and represents the largest population of homeless people in New York City since the Great Depression of the 1930s. Sadly, this figure represents only those homeless individuals seeking shelter in the New York City municipal shelter system and does not include the thousands of unsheltered homeless people sleeping in the streets, subway system, and other public spaces.

In addition to living population demographics, reported deaths in New York City by gender and race\(^9\) are provided in Table 5. This information was taken from the New York State Department of Health Statistics website, 2014 statistics. (https://www.health.ny.gov/statistics/vital_statistics/2014/#mort).

<table>
<thead>
<tr>
<th></th>
<th>White</th>
<th>Black</th>
<th>Hispanic</th>
<th>Other</th>
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<tbody>
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<td>Male</td>
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<td>6,874</td>
<td>4,845</td>
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<td>29,566</td>
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<td></td>
<td>(24.5%)</td>
<td>(11.4%)</td>
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<td>4,713</td>
<td>2,500</td>
<td>30,846</td>
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<td>(12.7%)</td>
<td>(7.8%)</td>
<td>(4.1%)</td>
<td>(51.1%)</td>
</tr>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
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<td></td>
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<td>(0.0%)</td>
<td>(0.0%)</td>
<td>(0.0%)</td>
<td>(0.0%)</td>
</tr>
<tr>
<td>Total</td>
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<td>14,545</td>
<td>9,558</td>
<td>5,540</td>
<td>60,413</td>
</tr>
<tr>
<td></td>
<td>(50.9%)</td>
<td>(24.1%)</td>
<td>(15.8%)</td>
<td>(9.2%)</td>
<td>(100%)</td>
</tr>
</tbody>
</table>

\(^9\) The terms "gender" and "race" are used by the New York State Department of Health and may not directly translate to biological sex and ancestry.
The Office of Chief Medical Examiner (OCME) in New York City is located in Manhattan and, although it has jurisdiction over all five boroughs, it primarily serves the borough of Manhattan. Established in 1918 as the first facility of its kind, the OCME has grown today to be one of the country’s largest morgues. Additionally, the office assists law enforcement with the investigation of crimes, deaths, and identities of missing persons. The OCME employs a Chief and 620 scientists and staff members that manage day-to-day operations including pathology, toxicology, serology, histology, DNA, and forensic anthropology. Included among the staff are 30 forensic pathologists that handle 12,000 bodies and conduct 5,500 autopsies annually (Goodman, 2015). In addition to their large caseload, the OCME is also responsible for the identification of mass fatality incidents such as those who perished in the attacks on the World Trade Center in 2001, the 2001 American Airlines flight 587 crash, and the 2003 Staten Island Ferry Crash.

The anthropology unit, housed within the OCME, has a staff of eight forensic anthropologists that serve all of New York City’s five boroughs. These staff members are primarily responsible for skeletal cases, although they are frequently consulted in soft tissue cases involving bone trauma or ambiguous biological characteristics, such as age and ancestry. Forensic anthropologists are responsible for a wide-range of tasks including scene recovery, photography, maceration of soft tissues, skeletal analysis of biological characteristics and trauma events, estimation of post-mortem interval, histology, and report writing. Forensic anthropology case reports are in-house peer-
reviewed by fellow anthropologists prior to final submission (Bradley Adams, Personal Communication).

There are also important large-scale undertakings at the OCME that require the skills of forensic anthropologists. For instance, a grant awarded from the National Institute of Justice allows the OCME to investigate cold cases that have accumulated over the years through the disinterment of human remains in Potters Field on Hart Island. The goal is to identify unknown individuals through anthropological methods as well as DNA sampling and analysis that were not available when these individuals were initially interred. In addition to this project, the staff at the OCME is constantly at work identifying the victims of 9/11. A special team of anthropologists within the unit specializes in the management of the hundreds of thousands of human remains as well as the identification processes associated with the victims of 9/11. These anthropologists work both at the OCME and at the repository within the newly constructed 9/11 memorial.

**Harris County, Texas**

With a 2014 population estimate of 4,441,370, Harris County, Texas is the third largest county in the United States and the largest county in Texas. Houston, the county’s seat, is the county’s largest city with a population of 2,196,000. Houston is also Texas’ largest city and the fourth largest city in the United States. Harris County occupies 1,703.48 square miles, making the population density of approximately 2,607
people per square mile. The county is situated on the Galveston Bay and its primary industry is energy, specifically, oil and natural gas as well as manufacturing and aeronautics. Its position along the Galveston Bay at the Gulf of Mexico and the Port of Houston allows for the mass export of goods. According to the U.S. Department of Commerce’s International Trade Commission, in 2013, the Port of Houston surpassed New York City for the top area of exportation of goods.

Houston is one of the country’s most diverse large cities. According to the 2010 US Census Bureau, 70% of Harris County’s population identified as “white,” with 31.9% reporting, “white alone, not Hispanic.” As with residents in New York City, this difference suggests that the term “white” here may indicate a difference in the meaning of the term “white” or some level of mixed ancestry. In contrast to New York’s data of a difference of 10% reporting “white” and “white only”, there is a 38.9% difference between these two categories in Harris County. This indicates a demographic difference between the two cities. The census also reported Harris County’s population as 41.6% “Hispanic/Latino,” 19.5% “black,” 6.8% “Asian,” 1.1% “American Indian and Alaskan Native,” and 0.1% “Native Hawaiian and other Pacific Islander.” Only 1.7% of respondents identified as being of “two or more races.” The census also found that 25% of Harris County’s residents are foreign born and the high number of “Hispanic/Latino” individuals is likely due to Harris County’s proximity to the Mexican border. According to Sharon Derrick, a forensic anthropologist at HCIFS, many Latin American migrants settle in Harris County to work.
The census results may also reflect a population influx that occurred in Harris County following the aftermath of Hurricane Katrina on New Orleans, Louisiana in 2005. The city of Houston alone absorbed approximately 250,000 people, many of them taking up permanent residence (Hamilton, 2010). The majority of Houston’s new residents were poor black and Vietnamese individuals from the most heavily impacted areas of New Orleans (Hamilton, 2010). Despite claims of increased crime in Houston from the arrival of new immigrants, crime in Houston was minimally impacted (Hamilton, 2010).

Houston is also home to 6,876 homeless persons (Coalition for the Homeless, 2014) a figure that fortunately, has been declining over the years. When Houston’s homeless population spiked 25% between 2010 and 2011, the U.S. Department of Housing and Urban Development prioritized assistance to the region to reduce the numbers, an effort that seems to be working.

In addition to living population demographics, reported deaths in Harris County by gender and race\textsuperscript{10} are provided in Table 6. This information was taken from the Texas Department of State Health Services website, 2014 statistics (https://www.dshs.texas.gov/chs/vstat/vs14/data.aspx#death).

\textsuperscript{10} The terms “gender” and “race” are used by the Texas Department of State and may not directly translate to biological sex and ancestry.
Table 6. 2014 Death Statistics (Harris County)

<table>
<thead>
<tr>
<th></th>
<th>White</th>
<th>Black</th>
<th>Hispanic</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Male</strong></td>
<td>6,477 (27.0%)</td>
<td>2,916 (12.1%)</td>
<td>2,421 (10.1%)</td>
<td>714 (3.0%)</td>
<td>12,528 (52.2%)</td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td>6,275 (26.2%)</td>
<td>2,782 (11.6%)</td>
<td>1,844 (7.7%)</td>
<td>563 (2.3%)</td>
<td>11,464 (47.8%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>12,752 (53.2%)</td>
<td>5,698 (23.7%)</td>
<td>4,265 (17.8%)</td>
<td>1,277 (5.3%)</td>
<td>23,992 (100%)</td>
</tr>
</tbody>
</table>

Harris County Institute of Forensic Science (HCIFS)

The Harris County Institute of Forensic Science is located in Houston, Texas and has jurisdiction over all of Harris County assisting local and federal law enforcement agencies to resolve crimes and unidentified forensic cases. The office employs a Chief Medical Examiner as well as a team of pathologists, anthropologists, and forensic scientists specializing in histology, toxicology, drug chemistry, and trace evidence analysis (including fire debris, gunshot residue and paint analysis). As of 2016, the HCIFS has obtained full lab accreditation through the American Society of Crime Laboratory Directors – Lab Accreditation Board (ASCLD-LAB).

The HCIFS employs four full-time forensic anthropologists and a group of interns and researchers that assist with casework when necessary. They have similar responsibilities as those at the New York City OCME, as they manage skeletal casework and assist the medical examiners with requests for biological and trauma analysis of skeletal materials in fleshy individuals. Anthropologists in this office perform a wide variety of tasks such as scene recovery, photography, soft tissue maceration, skeletal analysis of biological characteristics and trauma events, estimation.
of postmortem interval, postmortem dental x-rays and dental comparisons, and report writing. Reports written at the HCIFS are also peer-reviewed.

The anthropology unit at HCIFS also runs the “Identification Unit” also called the “ID Unit.” The ID Unit is made up of HCIFS forensic anthropologists and an Identification Specialist who participates in and tracks the identification progress of each case. This division aggressively attempts to identify both skeletal and soft tissue cases that come into the morgue by immediately distributing information about the decedent to the National Information Crime Center, National Missing and Unidentified Persons System, and to the National Association of Medical Examiners Unidentified Decedent website. In addition, the ID Unit issues a comprehensive “Unidentified Decedent Flier” to local law enforcement and missing person’s units. The Unidentified Decedent Flier is also posted on the HCIFS website and can be accessed by anyone wishing to locate a missing loved one. The ID Unit is also responsible for tracking down family members of deceased individuals to inform of death. When efforts to locate next of kin are not successful, the Identification Specialist releases the name of the decedent to local television and newspaper media for help. If the individual continues to be unidentified, the body is released for burial in the Harris County Potters Field, newly located in Crosby, Texas. Although some cases remain unidentified, the ID Unit is extremely successful and most cases are resolved quickly (Sharon Derrick, personal communication).
Pima County, Arizona

With a 2014 population estimate of 1,004,516, Pima County, Arizona is the second largest county in Arizona and the 53rd most populous metropolitan area in the United States. Tucson, the county’s seat, is the county’s largest city with a population of 527,972 and the second largest city in the state. Pima County occupies 9,187.04 square miles, making the population density approximately 109 people per square mile.

According to the 2010 US Census Bureau 85.5 % of Pima County’s population identified as “white,” with 53.3% of those reporting, “white alone, not Hispanic.” As with residents in New York City and Harris County, this difference suggests that the term “white” here may indicate a particular interpretation of the term “white” or some level of mixed ancestry. Similar to Harris County’s data of a 38.9% difference between these two categories, Pima County shows a difference of 32.2% between these categories. These figures stand in contrast to New York’s demographic data of a difference of only 10% reporting “white” or “white alone, not Hispanic.” The census also reported Pima County’s population as 36.1% “Hispanic/Latino,” 4.1% “black,” 3.1% “Asian,” 4.3% “American Indian and Alaskan Native,” and 0.2% “Native Hawaiian and other Pacific Islander.” Only 2.8% of respondents identified as being of “two or more races.” The census also found that 12.8% of Pima County’s residents are foreign born and the high number of “Hispanic/Latino” individuals in the area is likely due to Pima County’s shared border with Mexico.

Pima County is home to the largest homeless population in Arizona. As of 2013, one out of every 131 (approximately 7,303) people in Pima County experienced
homelessness in 2013 (Homelessness in Arizona Annual Report, 2013). According to the report, 44% of the adult homeless population is over the age of 45 and 12% are families with children. Among homeless adults, 55% reported substance abuse and 46% suffer from mental or physical disabilities. A large majority of the homeless (5,501) are listed as “white” and 29% of all homeless (2,195) reported themselves to be of “Hispanic” ethnicity.

In addition to living population demographics, reported deaths in Harris County by gender and race are provided in Table 7. This information was taken from the Arizona Department of Health Services website, 2014 statistics (http://www.azdhs.gov/plan/report/ahs/2014/index.php?pg=counties).

Finally, Pima County has experienced an influx of undocumented border crossers as its location is situated along the southern border of the United States. This

<table>
<thead>
<tr>
<th>Table 7. 2014 Death Statistics (Pima County)</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>---</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

11 The terms “gender” and “race” are used by the Arizona Department of Health Services and may not directly translate to biological sex and ancestry.
area of the U.S. was part of a larger land deal acquired from Mexico in 1854, known as the Gadsden Purchase and spans 261 miles from the border of New Mexico to the Yuma county line. This area is known as the Tucson sector. Pima County contains portions of the Tohono O’odham Nation, the San Xavier Indian Reservation, and the Pascua Yaqui Indian Reservation. The Tohono O’odham Nation is the second largest Indian reservation in the United States encompassing over 2.7 million acres of land in Arizona as well as land over the border into Mexico. Pima County is within in the Sonoran Desert, a main route for border crossers entering the United States from Mexico. The Tohono O’odham reservation straddles 75 miles of the U.S./Mexican border where approximately 1,500 undocumented migrants pass each day (Pyclik and Leibig, 2005). The U.S. government granted the nation its sovereignty in 1937 but Border Patrol agents regularly traverse the border along the reservation. Members of the tribe could freely cross the border until the 1990s when the U.S. began to see a rise in illegal immigration, but now residents of the reservation need to provide proof of tribal membership to cross the border. (Briefing Before the Arizona Advisory Committee to The U.S. Commission on Civil Rights, 2002). Despite increased Border Patrol presence, the Tohono O’odham reservation is the state’s top entry point for undocumented migrants Briefing Before the Arizona Advisory Committee to (The U.S. Commission on Civil Rights, 2002).

With its close proximity to Mexico and being along a route used for border crossings, the Pima County Office of the Medical Examiner experiences a host of challenges in identifying the individuals that perish along the southern border.
The Pima County Office of the Medical Examiner is located in Tucson, Arizona and has jurisdiction over all of Pima County as well as 10 neighboring counties (Apache, Cochise, Gila, Graham, Greenlee, La Paz, Navajo, Pinal, Santa Cruz, and Yuma). The Pima County Office of the Medical Examiner assists local and federal law enforcement agencies, including Border Patrol, to resolve crimes and unidentified cases. The office employs a Chief Medical Examiner as well as a team of pathologists and medicolegal death investigators, one forensic anthropologist, and one rotating post-doctoral forensic anthropologist.

The forensic anthropologists are responsible for the examination of all skeletal and decomposed or mummified remains, including the remains of suspected undocumented border crossers (UBCs). Unlike the medical examiners' offices in New York City and Harris County, the PCOME handles casework of Arizonans as well as a large number of UBCs. There has been a marked increase in the number of migrants crossing the border into Arizona due to an increased Border Patrol presence along migrant corridors in Texas and California, forcing UBCs through the dangerous Sonoran Desert who then succumb primarily to heat-related illnesses (Anderson, 2008). Today, UBCs represent the majority of anthropology cases in Pima County. For example, UBC cases totaled 129 out of the entire 149 anthropology cases in 2014 alone. Since 2001, there have been 2,330 suspected border crosser cases with 65% (1,504) of those cases ending in successful identifications, while 35% (826) are unidentified. According to
Anderson (2008) the vast majority (92%) of unsuccessful migrants were identified as Mexican Nationals.

The anthropologists at the PCOME perform a wide variety of tasks such as scene recovery, photography, soft tissue maceration, skeletal analysis of biological characteristics and trauma events, estimation of the postmortem interval, postmortem dental x-rays and dental comparisons, and report writing. Due to the large caseload, the two anthropologists are typically not available to conduct scene recoveries on most, if not all, UBC cases along the border. Rather, they rely upon Border Patrol, local law enforcement, and the general public to recover and transport remains to the PCOME. Unlike the offices in New York City and Harris County, anthropology reports at the PCOME are not peer-reviewed, but post-doc reports are available for peer-review by the full-time anthropologist upon request.

The undocumented migrant situation along the border requires constant communication with border patrol and the Mexican Consulate. The staff at the PCOME meets once a week with representatives of the Mexican Consulate to report new UBC cases, review pending UBC cases, and exchange information helpful in the successful resolution of unidentified cases. To assist the identification process, the Mexican Consulate attempts to make contact with potential family members of victims to obtain DNA samples and view personal effects. DNA analyses are funded by the Mexican government and conducted on all UBC remains and possible family members for comparison purposes. The UBC situation in Pima County is unique and no other office in the country deals with this amount of unidentified individuals along the border.
CHAPTER FIVE

EXPECTATIONS AND RESEARCH AIMS

The aim of this study is to evaluate the accuracy of resolved forensic anthropology case reports from three urban medical examiners’ offices with large skeletal caseloads. This evaluation is the first of its kind and will provide the anthropological community with an understanding of the power and limitations of scientific methods in practice. Ancillary to this goal is to understand how the use of biological ancestry to estimate race translates to social race categories in forensic casework. A second aim of this study is to analyze the skeletal analysis of unresolved casework to identify potential reasons why those cases persist as unresolved.

Forensic anthropologists typically examine the accuracy of individual methods used to establish a biological profile by testing the various methods on skeletal populations other than the ones used to develop the method. These studies are controlled validation tests for the purpose of measuring a method’s applicability to a particular population group (refer to the previous chapter for examples). However, until now, these studies have been limited to evaluating specific components of the biological profile. There has yet to be a study evaluating the accuracy of the biological profile in its entirety from forensic anthropology casework.
The following expectations and research goals address the accuracy of the anthropological report and identify specific challenges associated with the methods used to develop a biological profile.

**Expectations and Research Aims**

**Expectation One**

This project is designed to discover if elements of the biological profile are difficult to assign in casework. The expectation, based on the literature, is that ancestry estimation will have a lower rate of accuracy than sex, age, and stature. The difficulties associated with estimating biological ancestry based on trait expression and using the results to assign social race categories, as outlined in the background chapters, will manifest in casework.

If this expectation is supported, then biological ancestry estimations are prone to misclassify social race descriptions provided by the reporting party. This information can be used to justify changes in missing persons reporting procedures as well as justify changes to the reporting of racial categories from the anthropological assessment of biological ancestry.
Expectation Two

Stature estimation, regardless of its accuracy will be uninformative. First, stature estimation methods have been largely developed for black and white individuals, while methods developed for Asian and Hispanic groups is limited. Second, self-reported stature is prone to inaccuracies making antemortem and postmortem comparisons imprecise (Wiley and Falsetti, 1991).

If this expectation is supported, then stature is either an unnecessary component of the biological profile unless the height of the individual falls outside the average height of the general population or forensic stature estimation methods should be improved.

Expectation Three

Unresolved casework will exhibit logistical challenges that hinder the anthropological evaluation of the biological profile. Examples include fewer skeletal elements available for analysis, damage to diagnostic elements, and/or ambiguous trait expression that confounds the evaluation of the biological profile.

Chapter Summary

This dissertation evaluates four elements of the biological profile in forensic practice with the goal of identifying areas that need improvement. The research
expectations outlined in this chapter are based upon the background information presented in chapters 2 and 3. A goal of this project is to help identify areas of anthropological assessment in casework that need improvement.
This chapter outlines the materials and methods utilized to analyze the data collected for this research. The conditions required for cases to be analyzed are discussed first. This will be followed by descriptive and analytical statistics for the casework examined including the number of resolved and unresolved cases, the number of cases with a presumptive identification, and the sex, age, and ancestry distributions of the dataset. Finally, methods for obtaining the data and an explanation of the analysis are described.

Forensic Anthropology Casework Sample

Selection Criteria and Final Sample

To be included in this study, forensic cases had to meet certain criteria. The data for this study were derived from written case reports summarizing the anthropological analyses of skeletal remains, where more than one component of the biological profile was examined. Typical autopsy or soft tissue cases where the anthropologist was consulted to establish the age of an individual (for example) were not considered. All
data is anonymized, as no names are associated with the records and no case numbers were used.

Two separate data sets were maintained and all data was recorded in excel spreadsheets for analysis. The first data set is comprised of forensic anthropology case reports of resolved cases. This data set includes postmortem information about the recovered skeletal materials and antemortem information about the missing person. Postmortem information was obtained through the report and includes the estimated sex, ancestry, age, and stature of the individual as well as information regarding the state of preservation and the approximate percent of recovered skeletal elements. Antemortem information includes the individual’s sex, ancestry, age, and stature. This information was collected from the files and databases in the medical examiners’ offices. In the rare instance this information was not provided, the missing person's report, other media (driver’s license, ID card, military ID, etc.) positively associated with the remains, or the death certificate was used. The death certificate was used to obtain antemortem information as a last resort, due to potential inaccuracies (Jennifer Love and Christian Crowder, personal communication). If available, data also includes the scientific method used to establish a positive identification. Examples of positive ID methods include, dental comparisons, radiograph comparisons, fingerprints, or DNA matching.

The second data set is comprised of forensic anthropology case reports of unresolved cases. This data set is limited to postmortem information about the individual. Postmortem information obtained from the forensic anthropology report
includes the estimated sex, ancestry, age, and stature of the unidentified individual as well as information regarding the state of preservation, and the approximate percent of recovered skeletal elements.

Keeping with these criteria, data from 204 resolved cases (47 from New York City, 47 from Harris County, and 110 from Pima County) is presented as well as 285 unresolved cases (42 from New York City, 4 from Harris county, and 239 from Pima County).

Data Analysis

Analysis of the first data set comprised of resolved cases consists of the direct comparison of the antemortem and postmortem information of each individual. Correct and incorrect estimations were tallied, counted, and converted to percentages for data dissemination. This examination documented similarities and discrepancies between the anthropological report and the actual physical characteristics reported to law enforcement. Biological sex was considered accurate if the assessment from the anthropology report matched the reported sex of the individual. Age was considered accurate if the age range provided in the anthropology report encompassed the age provided of the individual in the antemortem information. Ancestry was considered accurate when the estimation provided by the anthropology report corresponded with the reported antemortem race of the individual (ex: European ancestry for an individual identified as white). Stature was considered accurate if the range provided in the report
encompassed with reported height of the individual. The accuracy of the biological profile was evaluated by these standards because these are the criterions by which the methods are expected to perform.

However, the accuracy of the biological assessment of ancestry is nuanced and requires explanation. For the purposes of this study, correct ancestry estimations are defined as the congruence between antemortem biological ancestry estimations and reported postmortem social race categories. For example, if the estimated biological ancestry of an unknown is listed as white, Caucasian, or European and the identified race of the individual is listed as either white, Caucasian, or European, with the understanding that these terms are interchangeable, then the estimation is considered correct. If the ancestry estimation did not match the antemortem race category (e.g. ancestry estimated as black and individual was Asian) then the estimation is considered incorrect.

There were a few other scenarios where ancestry was considered correct even though the anthropological assessment did not exactly match the antemortem description. First, individuals estimated as two or more races (e.g. white or Hispanic) but the antemortem information for those individuals reported one but not both of those races, were scored as correct. The rationale behind this decision is because by providing two or more ancestry estimates, the anthropologist observed skeletal traits consistent with both groups. The anthropologist, in an effort to include, rather than exclude a potential match, included both ancestral groups in the final assessment of ancestry. In a second scenario, the ancestry assessment may indicate a degree of
admixture (ex: black and white admixture). The skeletal ancestry assessment may be correct biologically (anthropologists observed traits consistent with both black and white individuals), even if the decedent was identified only as one. The rationale here is that anthropologists use the term admixture or will often classify the unknown into multiple ancestries if the skeletal materials exhibit traits found in multiple ancestral groups or have ambiguous phenotypes not typical of one ancestral group. The reason anthropologists claim admixture when they observe the blending of traits is to acknowledge the variation they observe and also to help ensure these individuals are not unintentionally excluded from possible identifications.

Chapter three discussed the differences between race and ancestry and several reasons for the variation of ancestral trait expression among population groups. First, morphological traits are non-concordant; second morphological traits are expressed in all populations in varying frequencies; and third, craniometric variation and skin color do not follow the same patterns of expression. Additionally, there is no standard application of ancestry estimation methods in forensic practice. There is no threshold of ancestral trait expression that needs to be met to classify an individual into a social race category. How many characteristics does it take to classify someone as white or black, or a mixture of the two? How many traits of one ancestry are enough for an anthropologist to declare that there is some admixture in a person? How does the anthropologist know when traits are expressed because there is admixture versus that person having a non-typical phenotype?
The use of the term admixture to explain traits that are supposed to exist in all population groups at varying frequencies is a way to reconcile these questions. This practice also has utility in Pima County. Here, the term admixed Native American is used to describe the Hispanic population of undocumented migrants. This term is preferred because Hispanic does not adequately describe the variation that exists within the Hispanic group and also because families of the deceased often do not identify with the Hispanic label for cultural and political reasons (Anderson, personal communication). As such, the families are more willing to accept the identification of their loved one if the deceased is described as admixed Native American (Anderson, personal communication). Lastly, the missing persons report differs across jurisdictions but allows the reporting party to either check the race category from a pre-prepared list of race categories or by filling in a blank space on the form that describes the race or ethnicity missing person. Some forms contain space for a description of the missing persons complexion. Examples can be found at:

http://lib.post.ca.gov/Publications/Missing_Persons_Forms/mp_report.pdf,
http://www.texasequusearch.org/report-a-person-missing/. Although missing persons reports do not restrict the number of check boxes that can be marked and the reporting party can indicate multiple races, the forms do not ask about ancestry. However, on some forms, immediately following the race categories exists a section for the reporting party to describe the skin tone of the decedent. This provides the authorities with additional information about what the person looks like.
To determine if a sex bias exists between correct and incorrect ancestry assessments among FORDISC classification results, a contingency tables and chi-square analysis was conducted for reports in each of the three offices examined for this study.

Finally, for informational purposes, records related to how the positive identification was established were tallied, counted, and converted to percentages to discern trends (e.g. DNA, radiographs, fingerprint, etc.).

Ultimately, this data will provide forensic anthropologists with vital information regarding the ability to apply forensic methods and the frequency of their application to casework.

Information from the second data set includes only postmortem information and was tallied, counted, and converted to percentages for data dissemination. The results were analyzed to help explain why the individual remains unidentified. These indicators may include missing skeletal elements, poor preservation, inability to analyze, or ambiguous findings (evaluated in the same manner as with resolved cases). The findings gleaned from the unresolved cases serve to identify any factors that may hinder identifications or consistently present themselves. For example, does the number of skeletal elements or the presence/absence of diagnostic skeletal elements impact the completeness of reports and the potential chance of a positive identification? To address this, a chi-square analysis was conducted to evaluate the difference in the percentage of remains recovered among resolved and unresolved cases. The methodological collection of this data from both resolved and unresolved cases will
greatly increase our understanding of forensic anthropological methods in practice and the challenges associated with identifying individuals.

Chapter Summary

The materials and methods selected for this dissertation are intentional and strategic. The offices of New York, Harris County, and Pima County encompass large urban areas that provide an opportunity to examine anthropological issues associated with the analysis of diverse populations. Concurrently, the medical examiners’ offices in these cities are ideal for research because they handle large skeletal caseloads and employ teams of forensic anthropologists that work collaboratively. The Pima County office provides a contrast to the offices in Harris County and New York City, as their caseload differs in demographics and there is no peer-review process for written anthropology reports. As a result, the direct comparison of casework within and between these offices will provide the forensic anthropology community with fundamental statistics that, regardless of the outcome, will better our understanding of forensic casework.
CHAPTER SEVEN

RESULTS

This chapter presents the results for the analyses described in chapter six. Vital
statistics for each medical examiner’s office are presented, including the demographics
of individuals in both resolved and unresolved cases. These demographics are followed
by the results describing the accuracy of the anthropological report in forensic
casework. A discussion of the results presented here is reserved for chapter eight.

Vital Statistics

This section presents the results of the analysis of fundamental statistics at the
medical examiners’ offices in New York City, Harris County, and Pima County. The
statistics are presented separately for each element of the biological profile. The
demographics of resolved cases are presented first followed by results from unresolved
cases. The demographics analyzed include the sex, ancestry, and age distributions of
casework followed by a summary of the anthropologist’s estimations of the remains.
Information regarding the completeness of the remains and how individuals were
positively identified is also given.

Second, the vital statistics for unresolved cases are described. The information
gleaned from the anthropological analysis of these unidentified individuals, although not
verified through a positive identification, will serve as a proxy for the demographics of these missing individuals.

**Descriptive Statistics of Resolved Cases**

There were a total of 204 cases that met the research criteria from the three study locations. There were 47 resolved cases from New York City, 47 resolved cases from Harris County, and 110 resolved cases from Pima County. Of the 110 individuals analyzed from Pima County, 22 (20%) were U.S. citizens and 88 (80%) were identified as undocumented border crossers. The following results make up the vital statistics for these locations that will be discussed in Chapter eight.

**Biological Sex Estimation**

*New York City Office of Chief Medical Examiner*

Of the total 47 individuals suitable for this analysis, antemortem data indicated 31 (66%) were male and 16 (34%) were female. As described in Chapter two, the pelvis is the primary region of the skeleton used for sex estimation. In New York City, sex estimations are primarily conducted using morphological characteristics of the pelvis as well as morphological and metric characteristics of the skull. Here, sex could be estimated through forensic anthropological methods in 44 out of 47 cases. The three cases in which sex was indeterminate included a 14-month-old baby, a 14-year-old
child, and a case of cremated bone fragments. In the remaining 44 cases, the pelvis, the skull, or both were available for sex estimation. There were no cases when metric analysis of postcranial elements was needed to estimate sex. In the 44 cases available for sex analysis, all were estimated correctly (31 males, 16 females) providing an accuracy rate of 100%.

**Harris County Institute of Forensic Sciences**

Of the total 47 individuals suitable for this analysis, antemortem data indicated 34 (72%) were male, 13 (28%) were female. As in New York City, sex estimations at the Harris County Institute of Forensic Science (HCIFS) were conducted using morphological characteristics of the pelvis as well as morphological and metric characteristics of the skull. Here, sex could be estimated in all 47 cases. In these cases, the pelvis, the skull, or both were available for sex estimation and there were no cases when metric analysis of other postcranial elements was needed to estimate sex. All cases at the HCIFS were estimated correctly (43 males, 13 females) providing an accuracy rate of 100%.

**Pima County Office of the Medical Examiner**

Of the total 110 individuals suitable for this analysis, antemortem data indicated 100 (91%) were male and 10 (9%) were female. The vast difference between the number of males and females in this population is due to the large number of males that
perish after crossing the southern border of the United States into Arizona. Sex estimations are primarily conducted using morphological characteristics of the pelvis as well as morphological and metric characteristics of the skull. Here, sex could be forensically estimated in 108 out of 110 cases. The two cases where sex was not estimated included one individual where sex was determined from soft tissue at autopsy and one individual that was a 14-year old juvenile. In the 108 cases where sex was estimated, the pelvis, the skull, or both were available for sex estimation. There were no cases when metric analysis of postcranial elements was needed to estimate sex. In all 108 cases available for sex analysis, all were estimated correctly (98 males, 10 females) providing an accuracy rate of 100%. Additionally, among the total resolved cases, 22 were U.S. citizens. Eighteen were male, four were female, and sex was estimated correctly in 22 out of 22 cases (100%).

Ancestry Estimation

New York City Office of Chief Medical Examiner

Of the 47 individuals analyzed, antemortem data indicated 27 (57%) were white, nine (19%) were black, four (9%) were Hispanic, three (6%) were Asian, and four (9%) lacked antemortem information about race. Of those four, all were estimated as white. Table 8 shows the breakdown of antemortem reported race combined with antemortem sex in this sample.
Table 8. Antemortem Race and Sex Demographics (NYC)

<table>
<thead>
<tr>
<th>Race</th>
<th>Sex</th>
<th>Number of Cases (out of 47)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Male</td>
<td>17</td>
<td>36%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>10</td>
<td>21%</td>
</tr>
<tr>
<td>Black</td>
<td>Male</td>
<td>6</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Male</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Asian</td>
<td>Male</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>2</td>
<td>5%</td>
</tr>
<tr>
<td>Unknown</td>
<td>Male</td>
<td>4</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

To estimate ancestry, New York City anthropologists routinely utilize non-metric traits of the skull summarized by Rhine (1990) in conjunction with metric analyses of the cranium and the use of FORDISC. Ancestry was estimated in 41 of 47 cases (87%). There are many reasons why ancestry may not be estimated. Cases not meeting criteria for ancestry estimation include cases without crania, children, and cases with extremely fragmented remains. In this sample, four of the six indeterminate ancestry estimations were missing crania and two were juveniles. Of the 41 cases where ancestry was estimated, 37 of those estimations could be compared with antemortem data for missing individuals and 36 (97%) yielded correct racial approximations. In this analysis, one case (3%) as incorrectly estimated for ancestry. Among the correct estimations, two indicated that the individual was either one race or another (e.g. “black or Hispanic”) and four indicated that the individuals were admixed (e.g. “white/Hispanic” or “white/black admixture”). These categories suggest that the anthropologists
interpreted biological traits of these skulls as consistent with multiple ancestries. Although no level of racial admixture was reported in the antemortem data of these cases, they are considered accurate estimations of ancestry because the results would not exclude the missing individual from being a possible match.

One incorrect estimation of ancestry occurred for a completely skeletonized individual. This individual was estimated as black, but antemortem information indicated he was Hispanic. Records suggest that his ancestry was difficult to estimate due to the cranium appearing to exhibit a mixture of black, white, and Asian morphological characteristics. However, FORDISC produced results that suggested this individual was white or Hispanic, correctly identifying population level characteristics.

FORDISC was used as a tool to help estimate ancestry in 33 out of 47 cases (70%) eligible for metric analysis. Twenty-nine (88%) of these 33 cases yielded interpretable FORDISC results while four cases (12%), were listed as inconclusive. Inconclusive results by FORDISC may indicate that the program produced results the anthropologist believed would not add informative value to the overall ancestry estimation. In the 29 cases where FORDISC was used as a tool to help estimate ancestry and could be compared to antemortem data for accuracy, 26 (90%) of the FORDISC results alone correctly estimated the antemortem information, while three cases (10%) contained FORDISC results that did not match antemortem descriptions of the decedent. In these cases, the anthropologist was able to interpret the FORDISC results appropriately and made a final estimation of ancestry that matched the
antemortem description of the decedent. In this analysis, each of the three inaccurate FORDISC results dealt with the Hispanic category. Table 9 illustrates the comparison between the results produced by FORDISC, the final anthropological estimation of ancestry, and the antemortem information of the decedent provided to the medicolegal system. Table 9 shows the final ancestry estimation provided by anthropologists as correct in these cases despite inconclusive or potentially inaccurate FORDISC results. In making the final assessment of ancestry, these findings suggest that the anthropologists preferred the morphological analysis of ancestry to the FORDISC results.

_Harris County Institute of Forensic Sciences_

Of the 47 individuals analyzed, antemortem data indicated 24 (51%) were white, 11 (23%) were black, nine (19%) were Hispanic, two (5%) were Asian, and one (2%) lacked antemortem information about race. That individual was estimated as white. Table 10 shows the breakdown of ancestry and sex in this sample.

**Table 9. Incorrect FORDISC Results (NYC)**

<table>
<thead>
<tr>
<th>Morphological Analysis</th>
<th>FORDISC Results</th>
<th>Final Ancestry Estimation</th>
<th>Antemortem Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Hispanic</td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td>Hispanic</td>
<td>White</td>
<td>Hispanic</td>
<td>Hispanic</td>
</tr>
<tr>
<td>White/Hispanic</td>
<td>Black</td>
<td>White/Hispanic</td>
<td>Hispanic</td>
</tr>
</tbody>
</table>
Table 10. Race and Sex Demographics (Harris County)

<table>
<thead>
<tr>
<th>Ancestry</th>
<th>Sex</th>
<th>Number of Cases (out of 47)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Male</td>
<td>15</td>
<td>32%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>9</td>
<td>19%</td>
</tr>
<tr>
<td>Black</td>
<td>Male</td>
<td>7</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4</td>
<td>9%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Male</td>
<td>9</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Asian</td>
<td>Male</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Unknown</td>
<td>Male</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

Similar to New York City, Harris County anthropologists routinely utilize non-metric traits of the skull summarized by Rhine (1990) in conjunction with metric analyses of the cranium and the use of FORDIS C. Ancestry was estimated in 44 of 47 cases (94%). In this sample, all three of the indeterminate ancestry estimations had fragmentary crania and two of the three were also burned or charred. There was one individual where ancestry was estimated, but was unable to be compared with antemortem information; therefore, in the 44 cases where ancestry was estimated, 43 of those estimations could be compared with antemortem data for missing individuals. Of the 43 cases where ancestry could be evaluated for accuracy, all 43 (100%) yielded correct racial approximations.

FORDISC was used as a tool to help estimate ancestry in 44 out of 47 cases (94%). In the 44 cases where FORDISC was used, 43 could be compared with antemortem information. FORDISC correctly estimated ancestry in 36 (84%) of these
cases while seven (16%) yielded incorrect estimations. Similar to the data from New York City, five of the seven inaccurate results produced by FORDISC concerned the Hispanic category. Table 11 illustrates the comparison between the morphological ancestry estimation, the results produced by FORDISC, the final estimation anthropological estimation of ancestry, and the antemortem information of the decedent provided to the medicolegal system.

Table 11 shows the final ancestry estimation provided by anthropologists as correct in these cases despite potentially inaccurate FORDISC results. With the exception of one case, the table shows the anthropologists preferred to include the FORDISC results in their final assessments of ancestry even when it differed from the morphological assessment. This strategy is often employed to ensure that the decedent is not unintentionally excluded as a possible match to a missing person.

<table>
<thead>
<tr>
<th>Morphological Analysis</th>
<th>FORDISC Results</th>
<th>Final Ancestry Estimation</th>
<th>Antemortem Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>White/Hispanic</td>
<td>Hispanic</td>
<td>White, possible Hispanic admixture</td>
<td>White</td>
</tr>
<tr>
<td>Asian</td>
<td>White</td>
<td>Asian, possible white admixture</td>
<td>Asian</td>
</tr>
<tr>
<td>White</td>
<td>Hispanic</td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td>Hispanic</td>
<td>American Indian</td>
<td>Hispanic (Amerindian)</td>
<td>Hispanic</td>
</tr>
<tr>
<td>Black</td>
<td>American Indian</td>
<td>Black, possible American Indian admixture</td>
<td>Black</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Black</td>
<td>Hispanic, possible admixture</td>
<td>Hispanic</td>
</tr>
<tr>
<td>White</td>
<td>Hispanic</td>
<td>White, Hispanic, or admixed white/Hispanic</td>
<td>White</td>
</tr>
</tbody>
</table>
Before presenting the results of this category, discussion of the unique demographics of the population at the Pima County Medical Examiner’s office is warranted. Recall from Chapter four that the anthropologists in Pima County are challenged with identifying unknowns in the local population as well as deceased migrants that cross America’s southern border. Due to the hot and dry desert climate where many of their cases are found, unknowns often arrive at the medical examiner's office in various stages of decomposition, typically skeletal, mummified, or both.

For migrants, there are many social, political, and biological factors that confound the identification process. Pima county anthropologists have identified biological traits that exist among the migrant population (see: Birkby et al., 2008) and have adjusted communication of biological findings to family members and foreign governments. Therefore, terminology used to describe ancestry in reports from Pima County is different than in other cities, as it reflects an underrepresented population. The information reported here reflects their terminology.

Among the 110 identified individuals, antemortem data provided the following vital statistics: 11 (10%) white, zero (0%) black, zero (0%) Asian, seven (6%) Hispanic, four (4%) Native American, 70 (63%) Mexican Nationals, seven (6%) Guatemalan Nationals, four (4%) Honduran Nationals, one (1%) El Salvadoran, one (1%) Costa Rican, one (1%) Latin American, one (1%) Mexican National/Tohono O’odham Nation, and three (3%) lacked antemortem information about race. Of those three, one was forensically estimated as white, one indicated that there was “some degree of Native
American,” and one was estimated as Admixed Native American (ANA). Table 12 shows the breakdown of antemortem reported race combined with antemortem sex in this sample.

Similar to New York City and Harris County, Pima County anthropologists routinely utilize non-metric traits of the skull summarized by Rhine (1990) in conjunction with metric analyses of the cranium and the use of FORDISC. However, many current methods to estimate ancestry do not adequately reflect the variation existing in the populations represented in the Pima County Medical Examiner’s Office (Birkby et al., 2008). To address this variation, Pima County anthropologists began to use the term “Admixed Native American” (ANA) in 2011 to describe individuals that may otherwise be considered Hispanic. For forensic anthropologists using term Hispanic typically implies that an individual displays a blend of characteristics consistent with individuals of Native American, European, and African ancestries (Anderson, 2008). The transition away from the term Hispanic in Pima County is philosophical and also biologically appropriate. Socially, Hispanic describes a cultural tradition or an ethnicity associated with Spanish speaking populations outside of Spain, not an ancestral category. The families of many individuals discovered along the southern border often do not identify with Hispanic culture or recognize admixture in their lineage (Bruce Anderson, personal communication). The anthropologists at Pima County found that families were more willing to accept an identification of a loved one when the term Admixed Native American, rather than Hispanic, was used to describe the deceased (Bruce Anderson, personal communication).
Table 12. Antemortem Race and Sex Demographics (Pima County)

<table>
<thead>
<tr>
<th>Race or Country of Origin</th>
<th>Sex</th>
<th>Number of Cases (out of 110)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Male</td>
<td>10</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Black</td>
<td>Male</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Male</td>
<td>6</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Asian</td>
<td>Male</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Native American</td>
<td>Male</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Mexican National</td>
<td>Male</td>
<td>67</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>Guatemalan National</td>
<td>Male</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>Honduran National</td>
<td>Male</td>
<td>4</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>El Salvadoran</td>
<td>Male</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Costa Rican</td>
<td>Male</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Latin American</td>
<td>Male</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Mexican National/Tohono O’odham</td>
<td>Male</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Unknown</td>
<td>Male</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1</td>
<td>1%</td>
</tr>
</tbody>
</table>
Ancestry was estimated in 100 of 110 cases (91%). Of the 100 cases where ancestry was estimated, 97 of those estimations could be compared with antemortem data for missing individuals. Of the 97 cases where ancestry could be evaluated for accuracy, all 97 (100%) yielded correct racial approximations. Again, for the purposes of this study, correct ancestry estimations are defined as the congruence between postmortem biological ancestry estimations and reported antemortem social race categories. For example, if the estimated biological ancestry of an unknown is listed as Admixed Native American (ANA), some degree of Native American, Hispanic, or Southwest Hispanic, with the understanding that these terms in this office are interchangeable, then the estimation is considered correct if the individual identified as a Mexican National, Honduran National, Hispanic, etc. in life.

FORDISC was used as a tool to help estimate ancestry in many cases, however, not all the FORDISC analyses were available in all files for analysis. Out of the 97 cases eligible for metric analysis comparable to antemortem data, FORDISC information was available for 54 (55%) cases. In these 54 cases, 27 (50%) of FORDISC results yielded correct estimates, while 27 (50%) of FORDISC results yielded inaccurate estimates.

Further analysis of the FORDISC results in Pima County provides interesting conclusions that correlate with the challenges associated with identifying Hispanic individuals. FORDISC classified 20 Admixed Native American individuals into Asian categories such as Japanese, Chinese, and Vietnamese. Table 13 illustrates the comparison between the morphological ancestry estimation, the results produced by
FORDISC, the final estimation anthropological estimation of ancestry, and the antemortem information of the decedent provided to the medicolegal system.

Table 13 shows that the morphological assessment of ancestry detected traits consistent with two or more ancestries and the term Admixed Native American was used to describe these observations. In the majority of these cases, FORDISC classified the unknowns into Asian groups. Given the demographics of the region and experience identifying undocumented border crossers, the final anthropological assessment relied on the morphological interpretation of features. Interestingly, of the five Guatemalan individuals that were assessed using FORDISC, none of them were classified as Guatemalan, a population group included in the FORDISC database. Two of the individuals were classified as Japanese, two were classified as Hispanic, and one was classified as Chinese. Further, two non-Guatemalan individuals were classified as Guatemalan by FORDISC. Table 14 highlights these results.

The Guatemalan sample in FORDISC consists of males and represents a small subset of the general Guatemalan population. FORDISC’s inability to correctly classify the Guatemalans in this sample does not mean the program is ineffective, rather it suggests that the variation within the Guatemalan population is greater than the variation represented among the current FORDISC population of Guatemalans.
### Table 13. Incorrect FORDISC Results (Pima County)

<table>
<thead>
<tr>
<th>Morphological Assessment</th>
<th>FORDISC Results</th>
<th>Final Ancestry Estimation</th>
<th>Antemortem Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southwest Hispanic</td>
<td>White</td>
<td>Southwest Hispanic</td>
<td>El Salvadoran</td>
</tr>
<tr>
<td>Native American or</td>
<td>Black</td>
<td>Native American or</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Southwest Hispanic</td>
<td>Vietnamese</td>
<td>Asian, probable</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Vietnamese</td>
<td>Admixed Native American</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Southwest Hispanic</td>
<td>Vietnamese</td>
<td>Probable Southwest</td>
<td>Mexican National</td>
</tr>
<tr>
<td>European</td>
<td>Japanese</td>
<td>Admixed European</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Japanese</td>
<td>Admixed Native American</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>White</td>
<td>European and Admixed Native American likely</td>
<td>Latin American</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Japanese</td>
<td>Admixed Native American</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Native American</td>
<td>Chinese</td>
<td>Native American/Asian</td>
<td>Native American</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Japanese</td>
<td>Admixed Native American</td>
<td>Hispanic</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Japanese</td>
<td>Admixed Native American</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Japanese</td>
<td>Some degree of</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>White</td>
<td>Admixed Native American</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Black</td>
<td>Admixed Native American</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Native American and Black</td>
<td>Admixed Native American, European, African</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Vietnamese</td>
<td>Admixed Native American</td>
<td>Hispanic</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Chinese</td>
<td>Admixed Native American</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Japanese</td>
<td>Admixed Native American</td>
<td>Guatemalan</td>
</tr>
</tbody>
</table>
### Table 13. Continued

<table>
<thead>
<tr>
<th>Morphological Assessment</th>
<th>FORDISC Results</th>
<th>Final Ancestry Estimation</th>
<th>Antemortem Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admixed Native American</td>
<td>Japanese</td>
<td>Admixed Native American</td>
<td>Honduran National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Chinese</td>
<td>Admixed Native American</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Japanese</td>
<td>Some degree of Native American</td>
<td>Hispanic</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Japanese</td>
<td>Admixed Native American</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Black</td>
<td>Admixed Native American</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Chinese</td>
<td>Some degree of Native American</td>
<td>Hispanic</td>
</tr>
<tr>
<td>Southwest Hispanic</td>
<td>Chinese</td>
<td>Southwest Hispanic</td>
<td>Guatemalan</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Japanese</td>
<td>Admixed Native American</td>
<td>Guatemalan</td>
</tr>
</tbody>
</table>

### Table 14. FORDISC Results Guatemalan (Pima County)

<table>
<thead>
<tr>
<th>Morphological Assessment</th>
<th>FORDISC Results</th>
<th>Final Ancestry Estimation</th>
<th>Antemortem Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic</td>
<td>Guatemalan</td>
<td>Southwest Hispanic</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Chinese</td>
<td>Primarily Asian, probable Southwest Hispanic</td>
<td>Guatemalan</td>
</tr>
<tr>
<td>Southwest Hispanic</td>
<td>Southwest Hispanic</td>
<td>Southwest Hispanic</td>
<td>Guatemalan</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Japanese</td>
<td>Admixed Native American</td>
<td>Guatemalan</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Guatemalan</td>
<td>Admixed Native American</td>
<td>Mexican National</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Hispanic</td>
<td>Admixed Native American</td>
<td>Guatemalan</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Hispanic</td>
<td>Admixed Native American</td>
<td>Guatemalan</td>
</tr>
</tbody>
</table>
Sex Bias Among FORDISC Ancestry Estimations – All Locations

To determine if a sex bias exists in the FORDISC results of ancestry, contingency tables and chi-squares were calculated for the calculations provided by the FORDISC analyses. The chi-squares were calculated using the following equation:

\[ \chi^2 = \frac{(ad) - (cd)(a+b+c+d)}{(a+b)(c+d)(b+d)(a+c)} \]

Table 15 displays the contingency table that provided the numerical values used for the chi-square analysis for sex bias of the FORDISC ancestry estimations for all sample locations.

The chi-square analysis revealed that the sex differences in the FORDISC calculations of these reports are non-significant, \((p > 0.05)\), indicating that no sex bias exists.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>55</td>
<td>24</td>
<td>79</td>
</tr>
<tr>
<td>Incorrect</td>
<td>41</td>
<td>8</td>
<td>49</td>
</tr>
<tr>
<td>Total</td>
<td>96</td>
<td>32</td>
<td>128</td>
</tr>
</tbody>
</table>
Age

*New York City Office of Chief Medical Examiner*

Of the 47 individuals analyzed in New York City, age was estimated in all cases and reported as a minimum age or as an age range. Antemortem data shows that 12 (26%) individuals were 25 years of age and under, 24 (51%) individuals were 26-64 years of age, and five (11%) individuals were reported as age 65 and over. Six (12%) individuals lacked antemortem age data. The youngest individual represented in the dataset was 14 months of age, and the oldest was 87 years of age.

Age estimations were typically reported as age ranges where the unknown presumably fell within. A variety of aging methods were used to estimate the diverse population of deceased individuals, as no one aging method alone should be used to estimate age. However, frequently used methods for age estimation of the adult skeleton include the Suchey-Brooks (Katz and Suchey, 1986; 1989) method of aging the pubic symphysis, as well the methods associated with aging the sternal end of the 4th rib (Iscan and Loth, 1984; 1986) when available. For this analysis, comparisons of antemortem and postmortem data were examined to determine if the reported age of the identified individual fell within the age range estimated by the anthropologist. Of the 41 estimations that could be compared with antemortem data, 40 (98%) were correct and one (2%) was incorrect. The incorrectly aged individual was a 56-year-old white male whose age was under-estimated by one year (age range reported was 40-55).
Among all of the 47 age estimations provided by anthropologists, 32 estimations were presented as true age range (e.g. 30-45 years) and 15 estimations were presented more generally as a minimum age (e.g. 55+) and were considered correct if the individual was at least that age. In reference to age ranges, the overall average length of the age range for this sample is 14.5 years. The average age range for individuals known to be 25 years of age and under is 6.8 years. The average age range for individuals known to be 26 and over is 15.5 years. Additional calculations were performed to determine the average age ranges for more specific age categories to determine if the age ranges differ for younger, middle, or older individuals. The average age range for individuals 21 years of age and under is 4.8 years. This average increases to 9.9 years for individuals 22-35 years of age, and again the average increases to 18.8 years for individuals 36 years of age and over. Table 16 illustrates these results.

Table 16. Age Estimation Results – Average Ages by Age Range (NYC)

<table>
<thead>
<tr>
<th>Estimated Age Range</th>
<th>Average Number of Years in Each Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 years and under</td>
<td>6.8 years</td>
</tr>
<tr>
<td>26 years and over</td>
<td>15.5 years</td>
</tr>
<tr>
<td>21 years and under</td>
<td>4.8 years</td>
</tr>
<tr>
<td>22-35 years</td>
<td>9.9 years</td>
</tr>
<tr>
<td>36 years and over</td>
<td>18.8 years</td>
</tr>
<tr>
<td>Overall for Sample</td>
<td>14.5 years</td>
</tr>
</tbody>
</table>
A total of 10 age estimations were recorded as a minimum age (e.g. 55+). This is a strategy used to estimate the age of older individuals, as they are typically more difficult to age, have damaged remains, or are represented only by a cranium or few other skeletal elements whereby aging techniques are limited (see Chapter two for a complete discussion). For example, one 39-year-old individual found fragmented and burned was estimated to be an adult. Since the age estimations for these individuals were recorded as a minimum age, they are considered separately, and not included in the average age range calculations shown in table 16.

Harris County Institute of Forensic Sciences

Of the 47 individuals analyzed at Harris County, age could be estimated in all cases. There were two (4%) individuals 25 years of age and under, 35 (75%) individuals 26-64 years of age, and 10 (21%) individuals aged 65 and over. The youngest individual represented in the dataset was 23 years of age, and the oldest was 86 years of age.

As in New York City, anthropologists in Harris County frequently use methods for age estimation of the adult skeleton that include the Suchey-Brooks (Katz and Suchey, 1986; 1989) method of aging the pubic symphysis as well the methods associated with aging the sternal end of the 4th rib (Iscan and Loth, 1984; 1986) when available. In addition to these methods, cranial suture closure (Meindl and Lovejoy, 1985; Nawrocki, 1998) was also routinely used in this office. Of the 47 total estimations that could be
compared with antemortem data, 40 (85%) were correct and seven (15%) were incorrect. Table 17 shows the anthropologically estimated age range compared to the age at death among the incorrect estimations.

Among all of the 47 age estimations provided by anthropologists, 37 estimations were presented as true age range (e.g. 30-45 years) and 10 estimations were presented more generally as a minimum age (e.g. 55+) and were considered correct if the individual was at least that age. In reference to age ranges, the overall average length of the age range for this sample is 16 years. The average age range for individuals known to be 25 years of age and under is 8.5 years. The average age range for individuals known to be 26 and over is 16.4 years. Additional calculations were performed to determine the average age ranges for more specific age categories to evaluate if the age ranges differ for younger, middle, or older individuals. The average age range for individuals 21-35 years of age is 11.3 years. This average increases to 17.5 years for individuals 36 years of age and over. Table 18 illustrates these results.

<table>
<thead>
<tr>
<th>Estimated Age</th>
<th>Age at Death</th>
<th>Sex</th>
<th>Reported Race</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-40 years</td>
<td>41</td>
<td>F</td>
<td>White</td>
</tr>
<tr>
<td>40-60 years</td>
<td>62</td>
<td>F</td>
<td>White</td>
</tr>
<tr>
<td>Middle-aged adult</td>
<td>83</td>
<td>M</td>
<td>Asian</td>
</tr>
<tr>
<td>35-45 years</td>
<td>23</td>
<td>M</td>
<td>Hispanic</td>
</tr>
<tr>
<td>30-45 years</td>
<td>26</td>
<td>M</td>
<td>Hispanic</td>
</tr>
<tr>
<td>45-65 years</td>
<td>69</td>
<td>M</td>
<td>Black</td>
</tr>
<tr>
<td>50-65 years</td>
<td>67</td>
<td>M</td>
<td>White</td>
</tr>
</tbody>
</table>
Table 18. Age Estimation Results – Average Ages by Age Range
(Harris County)

<table>
<thead>
<tr>
<th>Estimated Age Range</th>
<th>Average Number of Years in Each Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 years and under</td>
<td>8.5 years</td>
</tr>
<tr>
<td>26 years and over</td>
<td>16.4 years</td>
</tr>
<tr>
<td>21-35 years</td>
<td>11.3 years</td>
</tr>
<tr>
<td>36 years and over</td>
<td>17.5 years</td>
</tr>
<tr>
<td>Overall for Sample</td>
<td>16 years</td>
</tr>
</tbody>
</table>

A total of eight age estimations for older individuals were recorded as a minimum age (e.g. 55+). Two individuals were estimated to be adults, as the nature of the recovered remains precluded more specific analysis. Since the age estimations for the above individuals were recorded as a minimum age, they are considered separately, and not included in the average age range calculations in table 18.

*Pima County Office of the Medical Examiner*

Of the 110 individuals analyzed in Pima County, age could be estimated in 108 cases with varying degrees of ranges. Antemortem data shows there were 14 (13%) individuals 21 years of age and under, 50 (46%) individuals 22-35 years of age, 39 (36%) individuals aged 35 and over, and five (5%) did not have antemortem data. The youngest individual represented in the dataset was 14 years of age, and the oldest was 74 years of age.

Age estimations were reported as age ranges where the unknown presumably fell within. As with the previous offices, a variety of aging methods were used to
estimate the diverse population of deceased individuals including the Suchey-Brooks
(Katz and Suchey, 1986; 1989) method of aging the pubic symphysis as well the
methods associated with aging the sternal end of the 4th rib (Iscan and Loth, 1984;
1986) when available. Of the 108 estimations that could be compared with antemortem
data, 95 (88%) were correct and 13 (12%) were incorrect. For the 22 U.S. citizens, age
was estimated correctly in 19 out of 22 cases (86%) and incorrectly in 3 (14%) cases.
Table 19 shows the anthropologically estimated age rage compared to the age at death
among the incorrect estimations.

Among all of the 108 age estimations provided by anthropologists, 106
estimations were presented as true age range (e.g. 30-45 years) and two estimations
were presented as a minimum age (e.g. 55+). In reference to age ranges, the overall

Table 19. Incorrect Age Estimation Results (Pima County)

<table>
<thead>
<tr>
<th>Estimated Age</th>
<th>Age at Death</th>
<th>Sex</th>
<th>Reported Race or Nationality</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-50 years</td>
<td>57</td>
<td>M</td>
<td>Mexican National</td>
</tr>
<tr>
<td>17-22 years</td>
<td>16</td>
<td>M</td>
<td>Mexican National</td>
</tr>
<tr>
<td>28-40 years</td>
<td>41</td>
<td>M</td>
<td>Mexican National</td>
</tr>
<tr>
<td>30-50 years</td>
<td>51</td>
<td>M</td>
<td>White/USA</td>
</tr>
<tr>
<td>28-40 years</td>
<td>25</td>
<td>M</td>
<td>Honduran National</td>
</tr>
<tr>
<td>35-50 years</td>
<td>34</td>
<td>M</td>
<td>Mexican National</td>
</tr>
<tr>
<td>25-40 years</td>
<td>24</td>
<td>M</td>
<td>Mexican National</td>
</tr>
<tr>
<td>30-50 years</td>
<td>27</td>
<td>F</td>
<td>Hispanic/USA</td>
</tr>
<tr>
<td>28-44 years</td>
<td>50</td>
<td>M</td>
<td>Mexican National</td>
</tr>
<tr>
<td>24-32 years</td>
<td>23</td>
<td>M</td>
<td>Costa Rican National</td>
</tr>
<tr>
<td>30-50 years</td>
<td>29</td>
<td>M</td>
<td>Mexican National</td>
</tr>
<tr>
<td>40-66 years</td>
<td>72</td>
<td>M</td>
<td>Native American/USA</td>
</tr>
<tr>
<td>30-50 years</td>
<td>51</td>
<td>M</td>
<td>Mexican National</td>
</tr>
</tbody>
</table>
average length of the age range for this sample is 15.9 years. The average age range for individuals known to be 25 years of age and under is 7.5 years. The average age range for individuals known to be 26 and over is 19.5 years. Additional calculations were performed to determine the average age ranges for more specific age categories to determine if the age ranges differ for younger, middle, or older individuals. The average age range for individuals 21 years of age and under is 5.9 years. This average increases to 14.9 years for individuals 22-35 years of age, and again the average increases to 22.1 years for individuals 36 years of age and over. Table 20 illustrates these results.

A total of two age estimations for older individuals were recorded as a minimum age (e.g. 55+). Since the age estimations for these individuals were recorded as a minimum age, they are considered separately, and not included in the average age range calculations in Table 20.

<table>
<thead>
<tr>
<th>Estimated Age Range</th>
<th>Average Number of Years in Each Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 years and under</td>
<td>7.5 years</td>
</tr>
<tr>
<td>26 years and over</td>
<td>19.5 years</td>
</tr>
<tr>
<td>21 years and under</td>
<td>5.9 years</td>
</tr>
<tr>
<td>22-35 years</td>
<td>14.9 years</td>
</tr>
<tr>
<td>36 years and over</td>
<td>22.1 years</td>
</tr>
<tr>
<td>Overall for Sample</td>
<td>15.9 years</td>
</tr>
</tbody>
</table>

Table 20. Age Estimation Results – Average Ages by Age Range (Pima County)
Stature

New York City Office of Chief Medical Examiner

Stature was calculated for 39 out of the 47 individuals in the dataset. Similar to age, stature was recorded as a range (in inches) rather than as a single number. All calculations for stature were performed in FORDISC using long bone measurements. The smallest stature range was reported as five inches and the largest stature range was reported as eight inches. The average stature range was 6.2 inches. Unfortunately, antemortem stature data is largely lacking in the dataset, as it was often absent in the case files. This indicates that stature does not seem to be noteworthy or useful to include with the other antemortem data when identifications are made. In all, there were only 27 antemortem stature records. Due to a lack of appropriate skeletal materials to conduct the analysis, three individuals with known antemortem statures were not evaluated for stature. In all, stature comparisons were made for 24 out of the 47 individuals in the dataset. Comparisons were determined by whether or not the reported stature fell within the stature range estimated by the anthropologist. Of the 24 individuals available for this kind of analysis, 22 (92%) were correct and two (8%) were incorrect. The incorrect estimations include an individual that was reported to be 77 inches and was underestimated by 2.6 inches while the other was reported to be 72 inches and was underestimated by 0.4 inches.
Harris County Institute of Forensic Sciences

Stature was calculated for 41 out of the 47 individuals in the dataset. Due to the lack of appropriate skeletal materials stature was not conducted for six individuals. All calculations for stature were performed in FORDISC using long bone measurements. The smallest stature range was reported as 2.5 inches and the largest stature range was reported as 16.9 inches. The average stature range was 5.2 inches. Similar to New York City, antemortem stature data is severely lacking in the dataset, again, as it does not seem to be noteworthy or useful to include as a part of the identification. In all, there were only 13 antemortem stature records; therefore stature comparisons were made for 13 out of the 47 individuals in the dataset. Comparisons were determined by whether or not the reported stature fell within the range estimated by the anthropologist. Of the 13 individuals available for stature analysis, 11 (85%) were correct and two (15%) were incorrect. The incorrect estimations include an individual that was reported as 71 inches that was underestimated by two inches and individual that was reported as 68 inches tall and was underestimated by four inches. However, this individual was measured at autopsy and cadaveric stature was recorded as 64 inches which corresponds with the anthropological stature range of 59.5 – 64.8 inches.

Since stature analysis is population specific, further analysis of the relationship between ancestry and stature was conducted to investigate whether incorrect estimations of ancestry resulted in incorrect stature estimations. There were a total of 10 cases where ancestry was inaccurate, but only three cases had stature estimations
that could be compared with living statures. In two out of three cases, living stature fell within the estimated age ranges.

Pima County Office of the Medical Examiner

Stature was calculated for 46 out of the 110 individuals in the dataset. Calculations for stature among non-Admixed Native American individuals were performed in FORDISC using long bone measurements. Stature calculations of individuals suspected to be UBCs classified as Admixed Native American were primarily conducted using a method developed by Sjovold, (1990), but FORDISC 3.0 was sometimes used. The smallest stature range was reported as two inches and the largest stature range was reported as 8.4 inches. The average stature range was 3.7 inches, smaller than the ranges reported by the offices in NYC and Harris County. The Sjovold (1990) method for stature estimation yielded small stature ranges that directly contributed to the number of incorrect stature estimations as antemortem stature fell mere inches outside the estimated ranges. Similar to New York City and Harris County, antemortem stature data is largely lacking in the dataset. In all, there were only 33 stature estimations that could be compared to reported antemortem stature information. Comparisons were determined by whether or not the reported stature fell within the stature range estimated by the anthropologist. Of the 33 individuals available for this analysis, 18 (55%) were correct and 15 (45%) were incorrect. The problems with forensic stature outlined in chapter two that apply to the results from New York City and
Harris County are confounded by the additional problems associated with identifying undocumented migrants. Of the 22 U.S. citizens, postmortem stature estimations could be compared to antemortem living stature in 13 out of 22 cases (59%). Of those, nine (69%) yielded correct stature estimations while four (31%) were incorrect. Table 21 presents the data associated with the inaccurate stature estimations in Pima County and shows that stature estimations largely underestimate the known statures of the decedents in these cases. There were only two cases where the stature was overestimated.

**Table 21. Inaccurate Stature Estimation Results (Pima County)**

<table>
<thead>
<tr>
<th>Stature Estimation</th>
<th>Antemortem Stature</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>60.9 – 64.0 inches*</td>
<td>66 inches</td>
<td>- 2 inches</td>
</tr>
<tr>
<td>69.6 – 72.8 inches</td>
<td>66 inches</td>
<td>+ 3 inches</td>
</tr>
<tr>
<td>61.5 – 65.5 inches*</td>
<td>66 inches</td>
<td>- 0.5 inches</td>
</tr>
<tr>
<td>64.2 – 67.8 inches *</td>
<td>70 inches</td>
<td>- 2.2 inches</td>
</tr>
<tr>
<td>64.0 – 67.6 inches</td>
<td>68 inches</td>
<td>-0.4 inches</td>
</tr>
<tr>
<td>63.0 – 67.4 inches</td>
<td>70 inches</td>
<td>- 2.6 inches</td>
</tr>
<tr>
<td>60.0 – 63.6 inches</td>
<td>65 inches</td>
<td>- 1.4 inches</td>
</tr>
<tr>
<td>63.7 – 67.3 inches</td>
<td>68.5 inches</td>
<td>- 1.2 inches</td>
</tr>
<tr>
<td>62.5 – 66.1 inches</td>
<td>67 inches</td>
<td>-0.9 inches</td>
</tr>
<tr>
<td>65.2 – 68.8 inches</td>
<td>63 inches</td>
<td>+ 2.2 inches</td>
</tr>
<tr>
<td>60.9 – 62.9 inches</td>
<td>64 inches</td>
<td>- 1.1 inches</td>
</tr>
<tr>
<td>66.1 – 69.7 inches</td>
<td>70 inches</td>
<td>- 0.3 inches</td>
</tr>
<tr>
<td>59.5 – 63.1 inches</td>
<td>68 inches</td>
<td>- 4.9 inches</td>
</tr>
<tr>
<td>67.9 – 70.9 inches*</td>
<td>71 inches</td>
<td>- 0.4 inches</td>
</tr>
<tr>
<td>63.7 – 67.3 inches</td>
<td>68 inches</td>
<td>- 0.7 inches</td>
</tr>
</tbody>
</table>

*indicates U.S. citizens.
Considerations for Identifications

There are several variables that influence the generation of the biological profile and subsequent identifications including, but not limited to, the percentage of skeletal elements recovered for analysis, the presence of the cranium, the ability to extract and successfully amplify DNA, and having access to antemortem radiographs for comparisons. The cranium is essential to the estimation of ancestry and is also often used in sex estimation. Additionally, without a cranium, comparison of dental radiographs or frontal sinuses cannot be made. This section outlines the amount and type of skeletal remains available for analysis as well as the identification methods used to resolve cases.

New York City Office of Chief Medical Examiner

Of the 47 cases available for analysis, the cranium was present in 40 (85%) of the cases, while the remaining seven cases (15%) did not have a cranium. In addition to the cranium, the percent of total remains recovered was recorded in four ranges, 1-25%, 26-50%, 51-75%, and 76-100% and was determined by visual inspection of photographs and descriptions within the reports. Table 22 shows the number of cases falling within these categories.

A more complete anthropological assessment of the biological profile as well as opportunities to compare antemortem radiographs increases with the number of skeletal
Table 22. Percent of Skeletal Remains Available for Analysis (NYC)

<table>
<thead>
<tr>
<th>Percent Available</th>
<th>Number of Cases (out of 47)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 25%</td>
<td>6</td>
<td>13%</td>
</tr>
<tr>
<td>26 – 50%</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>51 – 75%</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>76 – 100%</td>
<td>36</td>
<td>77%</td>
</tr>
</tbody>
</table>

elements recovered. As noted in Table 22, 77% of the resolved cases in New York City represent mostly complete sets of skeletal remains.

Since the biological profile generated from the anthropological analysis of remains is not sufficient for positive identification, the methods used to make positive identifications were recorded to discern any trends. Table 23 shows the number of cases in where different identification methods were employed.

DNA was used to confirm identifications in 52% of cases. DNA comparison is possible through the successful extraction and amplification of the decedents DNA. The sample is compared to DNA known to have belonged to the decedent in life (such as from a toothbrush or hairbrush) or from DNA provided by a biologically close family member. Successful DNA comparisons can also be made if the decedent’s DNA is stored in the Combined DNA Index System (CODIS).

The unknown category represents 27% of the cases at New York City. The available records did not indicate how the decedents were eventually identified but of those 13 unknown cases, DNA sampling was confirmed in five cases; three cases had
circumstantial evidence associated with the remains, and one was confirmed to have had dental charting.

Harris County Institute of Forensic Sciences

Of the 47 cases available for analysis, the cranium was present in 46 (98%) of the cases, while the remaining case representing 2% of the dataset did not have a cranium. In addition to the cranium, the percent of total remains recovered was recorded in four ranges, 1-25%, 26-50%, 51-75%, and 76-100% and was determined by visual inspection of photographs and descriptions within the reports. Table 24 shows the number of cases falling within these categories and notes that 81% of the resolved cases in Harris County represent mostly complete sets of skeletal remains.
Table 24. Percent of Skeletal Remains Available for Analysis (Harris County)

<table>
<thead>
<tr>
<th>Percent Available</th>
<th>Number of Cases (Out of 47)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 25%</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>26 – 50%</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>51 – 75%</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>76 – 100%</td>
<td>38</td>
<td>81%</td>
</tr>
</tbody>
</table>

As with New York City, the method for positive identification was recorded to discern any technological trends. Table 25 shows the number of cases where different identification methods were employed.

The unknown category represents only 6% of the cases in Harris County. The available records did not indicate how the decedents were eventually identified, but of those 15 unknown cases, a DNA sample was taken in one case and strong circumstantial evidence associated with two cases was noted.

*Pima County Office of the Medical Examiner*

Of the 110 cases available for analysis, the cranium was present in 107 (97%) of the cases, while the remaining three cases (3%) did not have a cranium. In addition to the cranium, the percent of total remains recovered was recorded in four ranges, 1-25%, 26-50%, 51-75%, and 76-100% and was determined by descriptions within the reports. Table 26 shows the number of cases falling within these categories and notes that 71% of the resolved cases in Pima County represent mostly complete sets of skeletal remains.
Table 25. Identification Method (Harris County)

<table>
<thead>
<tr>
<th>Identification Method</th>
<th>Type</th>
<th>Number of Cases (out of 47)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA</td>
<td>CODIS</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Comparison</td>
<td>18</td>
<td>17%</td>
</tr>
<tr>
<td>Radiographs</td>
<td>Medical</td>
<td>6</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Dental</td>
<td>8</td>
<td>17%</td>
</tr>
<tr>
<td>Fingerprints</td>
<td></td>
<td>8</td>
<td>17%</td>
</tr>
<tr>
<td>Surgical Implants</td>
<td></td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Circumstantial Evidence</td>
<td></td>
<td>4</td>
<td>9%</td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
<td>3</td>
<td>6%</td>
</tr>
</tbody>
</table>

Similar to New York City and Harris County, data was recorded to discern trends regarding how the decedent was positively identified. Table 27 shows the number of cases where different identification methods were employed and notes that DNA comparison was used to positively identify the majority of individuals in these cases. Familial DNA comparisons are primarily used to identify the remains of undocumented border crossers. The Pima County Medical Examiner’s Office and the Mexican Consulate work cooperatively to obtain DNA samples from family members.

**Summary of Resolved Cases for NYC, Harris County, and Pima County Combined**

Taken together, the accuracy of the biological profile can be summarized as follows:

1) Sex was accurate in all of the resolved cases analyzed in this research.
Table 26. Percentage of Skeletal Remains Available for Analysis (Pima County)

<table>
<thead>
<tr>
<th>Percent Available</th>
<th>Number of Cases (out of 110)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 25%</td>
<td>8</td>
<td>7%</td>
</tr>
<tr>
<td>26 – 50%</td>
<td>8</td>
<td>7%</td>
</tr>
<tr>
<td>51 – 75%</td>
<td>16</td>
<td>15%</td>
</tr>
<tr>
<td>76 – 100%</td>
<td>78</td>
<td>71%</td>
</tr>
</tbody>
</table>

Table 27. Identification Method (Pima County)

<table>
<thead>
<tr>
<th>Identification Method</th>
<th>Type</th>
<th>Number of Cases (out of 110)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA</td>
<td>CODIS</td>
<td>5</td>
<td>4%</td>
</tr>
<tr>
<td>Radiographs</td>
<td>DNA Comparison</td>
<td>70</td>
<td>64%</td>
</tr>
<tr>
<td>Medical</td>
<td>5</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Dental</td>
<td>8</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>Fingerprints</td>
<td>12</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Surgical Implants</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Circumstantial Evidence (Includes personal effects and tattoos)</td>
<td>7</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>3</td>
<td>3%</td>
<td></td>
</tr>
</tbody>
</table>
1) Ancestry estimation was accurate in 176 out of 177 resolved cases (99%) where ancestry estimations could be compared to antemortem descriptions.
   a. Morphological assessment of ancestry was accurate in 176 out of 177 resolved cases (99%)
   FORDISC was accurate in 89 out of 130 resolved cases (68%) where FORDISC results could be compared to antemortem descriptions. Thirty-
   b. four out of the total 37 incorrect FORDISC estimations (92%) involved the Hispanic category.
2) Age range estimations were accurate in 175 out of 190 resolved cases (92%) where ranges used to estimate age could be compared to antemortem descriptions.
3) Stature calculations were accurate in 51 out of 70 resolved cases (73%) where stature estimations could be compared to antemortem descriptions.
4) The biological profiles of the U.S. citizens in Pima County show similar rates of accuracy as compared to the biological reports of the U.S. citizens in New York City and Harris County.

Vital Statistics for Unidentified Individuals

Statistics for unresolved cases for both New York City and Harris County are presented together because there were 42 unresolved cases from New York City but only three unresolved cases from Harris County. Statistics for Pima County are
presented separately, as there are 239 unresolved cases represented in the dataset that also characterize a demographic consisting primarily of unidentified border crossers. In total, there are 284 unresolved cases available for this examination.

The background chapter details several factors that may prohibit the successful identification of human remains in the medicolegal system. The information provided here serves to identify potential anthropological explanations only as to why these individuals have yet to be identified. Before exploring these potential reasons, the demographics, as estimated by the anthropologists, are presented first; a complete examination of these results will be presented in the discussion chapter.

New York City Office of Chief Medical Examiner and Harris County Institute of Forensic Sciences Combined

Biological Profile

The demographic information for 45 unresolved cases in NYC and Harris County from 2005 to 2014 is presented here. Of these cases, there are a total of 24 (53%) males, 17 (38%) females; three (7%) of unknown sex, and one (2%) individual estimated as being a “probable male.” Amelogenin results were available for 23 (51%) of the 45 original cases. Amelogenin results showed that there were no incorrect estimations of sex by forensic anthropologists; however, one individual\textsuperscript{12} whose sex could not be estimated was identified as female by the amelogenin results. Since

\textsuperscript{12} Less than 50\% of the remains recovered; the skull and the pelvis were not recovered.
amelogenin information was not reported in all cases, the estimations by anthropologists in these cases serve as the biological sex statistics.

Statistics of ancestry are derived from anthropological estimation. Results indicate that 11 (25%) of the individuals are estimated as white, three (6%) are estimated as black, two (4%) are estimated as Hispanic, one (2%) is estimated as possible Hispanic, one (2%) is estimated as Asian, six (14%) are estimated as admixed, six (14%) are estimated as belonging to one race or possibly another, and two (4%) are estimated to be not white. There were 13 (29%) individuals where ancestry was indeterminate or not estimated (12 had no skull). Table 28 shows the breakdown of ancestry and sex for the unidentified sets of remains.

The sex and race demographics show a relatively even distribution of ancestries among the unknown except that white males and females represent a slight majority over other groups. Among the population of unresolved cases, the admixed and two or more ancestries categories are also represented in large numbers.

FORDISC was used as a tool to help estimate ancestry in 28 (62%) cases. FORDISC classified 11 individuals as white, five as black, one as Asian, two as Hispanic, one as white and black, one as not white, one as American Indian and Japanese, one as “Amerindian, Chinese, Hispanic and Japanese groups,” and five cases yielded inconclusive results. Of the 11 individuals classified as white, the forensic anthropologist estimated nine as white, while two were ultimately estimated as admixed. Among the five cases classified as black, the forensic anthropologist ultimately estimated two as black and three having varying degrees of admixture. The individuals
classified in the Asian or Amerindian groups were estimated by FORDISC as having a variety of ancestry combinations.

The age ranges provided by the anthropologists are used to evaluate the age distributions among the unresolved cases. There were 31 out of 45 cases that included age ranges. The average age range of these individuals is 13.6 years.

There were two cases assigned age ranges where the skeletal elements were represented by only the cranium or just the cranium and a few non-diagnostic skeletal elements. The average estimated age of these cases, using cranial suture and dental analyses, is 18.5 years. Among the unresolved cases, five individuals were estimated as “adult,” one was estimated as “middle to old adult,” three were estimated as “young to middle aged adult,” one was estimated as a “young adult” and five individuals were estimated as a minimum age and over (e.g. 30+).

Stature was estimated in 36 (80%) of 45 cases. Of the remaining 9 (20%) cases, two were soft tissue cases where stature were measured by the medical examiner, one was a juvenile, and six did not have skeletal elements suitable to conduct stature estimations.

**Completeness of Remains**

The total percentage of the body recovered in forensic contexts affects the evaluation of the biological profile and affects the identification rate (Komar and Potter, 2007). When fewer skeletal elements are available for study, there is an increased risk
Table 28. Ancestry and Sex Demographics – Unresolved Cases (NYC and Harris County Combined)

<table>
<thead>
<tr>
<th>Ancestry</th>
<th>Sex</th>
<th>Number of Cases (Out of 45)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Male</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>6</td>
<td>13%</td>
</tr>
<tr>
<td>Black</td>
<td>Male</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>2</td>
<td>5%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Male</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Possibly Hispanic</td>
<td>Male</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Asian</td>
<td>Male</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Admixed</td>
<td>Male</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Two or More</td>
<td>Male</td>
<td>4</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>2</td>
<td>5%</td>
</tr>
<tr>
<td>Not White</td>
<td>Male</td>
<td>2</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>Male</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>Indeterminate</td>
<td>3</td>
<td>7%</td>
</tr>
</tbody>
</table>
that important information about the decedent will be undiscovered. Of the 45 unresolved cases in NYC and Harris County, 32 (71%) of the remains included a cranium or portions of a cranium, while 13 (29%) did not. As described in the background chapter, the absence of a cranium has deleterious effects on the anthropological estimation of sex and ancestry. Additionally, the absence of dentition and/or incomplete or fragmentary cranial remains makes positive identification with antemortem dental and frontal sinus radiographs impossible. Table 29 shows the percentage of the body recovered describing the same criteria used for the resolved cases. The data includes four ranges, 1-25%, 26-50%, 51-75%, and 76-100% and was determined by skeletal inventories, visual inspection of photographs, and descriptions of the remains provided within the reports.

The percentage of remains recovered for the unresolved cases is variable with the majority, 22 (49%), having more than 75% of the total remains recovered. The second largest category, at 17 (37%) cases, is the one that represents cases where the fewest number of skeletal elements were available for analysis. Of these cases, four are represented by only a cranium, portions of a cranium, or by a cranium and a small number of non-diagnostic skeletal elements.
Table 29. Percentage of Skeletal Remains Available for Analysis – Unresolved Cases (NYC and Harris County Combined)

<table>
<thead>
<tr>
<th>Percent Recovered</th>
<th>Number of Cases (Out of 45)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 25%</td>
<td>17</td>
<td>37%</td>
</tr>
<tr>
<td>26 – 50%</td>
<td>3</td>
<td>7%</td>
</tr>
<tr>
<td>51 – 75%</td>
<td>3</td>
<td>7%</td>
</tr>
<tr>
<td>76 – 100%</td>
<td>22</td>
<td>49%</td>
</tr>
</tbody>
</table>

Pima County Office of the Medical Examiner

*Biological Profile*

The demographic information for 239 unresolved cases in Pima County from 2010 to 2013 is presented here. Of these cases, there are a total of 194 (81%) males, 39 (15%) females, and six (3%) of unknown sex. Among those of unknown sex, one was estimated as probable female, two were estimated as probable male, and three were indeterminate. Amelogenin results were available for 173 (72%) of the 239 original cases. Amelogenin results showed that there were six (3%) incorrect estimations of sex by forensic anthropologists; four males were estimated as females, and two females were estimated as males. All of these individuals are believed to be undocumented border crossers. Each of the six cases were represented by less than 25% of the skeleton and only two cases were metrically conducive to sex analysis using FORDISC. FORDISC accurately predicted the sex of these two individuals (male), but the final sex estimation by the anthropologist was female. Since amelogenin
information was not reported in all cases, the estimations by anthropologists in these cases serve as the basis for the biological sex statistics.

Statistics of ancestry in unresolved cases are derived from anthropological estimation only. The demographic composition of the unknown cases in Pima County is different than those of NYC and Harris County. Results indicate that only one (0.005%) of the unresolved cases is estimated as white, zero (0%) are estimated as black, nine (4%) are estimated as Hispanic, one (0.005%) is estimated as Asian, 78 (33%) are estimated as Southwest Hispanic, 12 (5%) are estimated as probable Southwest Hispanic, one (0.005%) is estimated as American Indian, and 30 (13%) were considered indeterminate. There are a number of cases where the individual was considered admixed. This is not to mean that the terms Hispanic and Southwest Hispanic used to describe the groups above do no imply a level of admixture, just that the anthropologists were more explicit in indicating that the individual displayed characteristics commonly found in more than one population group.

The following terms reflect the language used by the anthropologists. Of the 239 unresolved cases 22 (9%) are estimated as Admixed Native American (ANA), 34 (14%) are estimated as admixed American Indian and European, three (1%) are estimated as admixed American Indian and African, one (0.005%) is estimated as admixed Indigenous Mesoamerican, five (2%) are estimated as Southwest Hispanic and American Indian, one (0.005%) is estimated as Hispanic and Amerindian mix, 14 (6%) are estimated as Southwest Indian/Hispanic, and one (0.005%) is estimated as Admixed Native American, possible African Admixture (Hispanic). Finally, there are
some cases where anthropologists indicated the possibility that an individual was either one race or another. Of the 235 cases nine (4%) are estimated as Caucasian or Southwest Hispanic, nine (4%) are estimated as American Indian or Southwest Hispanic, two (1%) are estimated as American Indian or admixed American Indian and European, one (0.005%) is estimated as Southwest Hispanic or African American, and one (0.005%) is estimated as probable Southwest Hispanic or European. Table 30 shows the distribution of ancestry and sex for these sets of remains.

The sex and ancestry demographics are vastly different than those of NYC and Harris County. Results from Pima County show an uneven distribution of males and female individuals, where males outnumber females considerably (194 males, 39 females). Ancestry estimation of these unidentified individuals reveals that a large number are recorded as Hispanic and Admixed Native American individuals.

One unknown is estimated as white and none estimated as black. These disparities likely reflect the demographics of the population among undocumented migrants who cross the US and Mexico border.

FORDISC was used as a tool to help estimate ancestry in 137 (57%) of cases. FORDISC classified 75 individuals as Hispanic, 15 as Guatemalan, 14 as Native American (Amerindian) 12 as white, eight as Vietnamese, five as Chinese, five as black, and three as Japanese. Of the 75 individuals classified as Hispanic by FORDISC, the forensic anthropologist ultimately estimated 45 as Hispanic or Southwest Hispanic. The remaining 30 cases were variations of admixture among Hispanic, Native American, and European groups. None of the individuals classified by FORDISC as being
## Table 30. Ancestry and Sex Demographics – Unresolved Cases (Pima County)

<table>
<thead>
<tr>
<th>Ancestry</th>
<th>Sex</th>
<th>Number of Cases (Out of 239)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Male</td>
<td>1</td>
<td>0.005%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Black</td>
<td>Male</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Male</td>
<td>7</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1</td>
<td>0.005%</td>
</tr>
<tr>
<td>Indeterminate</td>
<td></td>
<td>1</td>
<td>0.005%</td>
</tr>
<tr>
<td>Asian</td>
<td>Male</td>
<td>1</td>
<td>0.005%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Southwest Hispanic</td>
<td>Male</td>
<td>59</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>19</td>
<td>8%</td>
</tr>
<tr>
<td>Probable Southwest Hispanic</td>
<td>Male</td>
<td>11</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1</td>
<td>0.005%</td>
</tr>
<tr>
<td>American Indian</td>
<td>Male</td>
<td>1</td>
<td>0.005%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Admixed Native American</td>
<td>Males</td>
<td>21</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4</td>
<td>1%</td>
</tr>
<tr>
<td>Admixed “other”</td>
<td>Male</td>
<td>50</td>
<td>21%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>10</td>
<td>4%</td>
</tr>
<tr>
<td>2 or more ancestries</td>
<td>Male</td>
<td>19</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3</td>
<td>1%</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>Male</td>
<td>24</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4</td>
<td>2%</td>
</tr>
<tr>
<td>Indeterminate</td>
<td></td>
<td>2</td>
<td>1%</td>
</tr>
</tbody>
</table>
Guatemalan, Vietnamese, Chinese, Black, or Japanese (n = 36) were estimated as such by anthropologists. Among these, 13 of 36 were estimated as Southwest Hispanic and the remaining 23 were estimated as being a variation of multiple or admixed ancestries. For example, individuals classified as black by FORDISC were estimated as (1) Southwest Hispanic or American Indian, (2) Admixture of American Indian (possibly with some African), (3) Southwest Hispanic or African American, (4) American Indian Admixture (possibly with African), and (5) Admixed American Indian and African.

The age ranges provided by the anthropologists are used to evaluate the age distributions among the unresolved cases. There were 205 out of 239 cases that included age ranges. The average age range of all these individuals is 15.9 years. There were 51 cases assigned age ranges where the skeletal elements were represented by only the cranium or just the cranium and a few non-diagnostic skeletal elements. The average estimated age of these cases, using cranial suture and dental analyses, is 17 years. Among the cases that did not include a range for the age, 13 individuals were estimated to be “adult,” one was estimated to be an “older adult,” and 21 individuals were estimated to be a minimum age and over (e.g. 30+).

Stature was estimated in 105 (44%) of 239 cases. Twenty-five (10%) cases arrived at the Pima County Medical Examiner’s Office in a state of decomposition that allowed for crown to heel measurements at autopsy and 109 (46%) cases did not have skeletal elements suitable to conduct stature estimations.
Completeness of Remains

Similar to the results from NYC and Harris County, the completeness of remains represented in the Pima County sample, affects the evaluation of the biological profile. Of the 239 unidentified cases in Pima County, 211 (88%) of the remains included a cranium or portions of a cranium, while 28 (12%) did not. The absence of a cranium has deleterious effects on the anthropological estimation of sex and ancestry. Additionally, the absence of dentition and/or incomplete or fragmentary cranial remains makes positive identification with antemortem dental and frontal sinus radiographs impossible. Table 31 shows the percentage of the body recovered describing the same criteria used for the identified cases. The data includes four ranges, 1-25%, 26-50%, 51-75%, and 76-100% and was determined by skeletal inventories, visual inspection of photographs, and descriptions of the remains provided within the reports.

The percentage of remains recovered for these cases is variable with the majority of cases, 111 (46%), having the least number of skeletal elements recovered. Of these cases, 73 are represented by only a cranium, portions of a cranium, or by a cranium and a small number of non-diagnostic skeletal elements. The second largest category, at 71 (30%) of the total cases, is where the majority of skeletal elements are available for analysis.

A contingency table and chi-square statistic was calculated to determine if there is a significant difference between the percentage of skeletal remains recovered in resolved and unresolved cases. Table 32 illustrates the contingency table.
Table 31. Percentage of Skeletal Remains Available for Analysis – Unresolved Cases (Pima County)

<table>
<thead>
<tr>
<th>Percent Available</th>
<th>Number of Cases (Out of 239)</th>
<th>Percentage of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 25%</td>
<td>111</td>
<td>46%</td>
</tr>
<tr>
<td>26 – 50%</td>
<td>29</td>
<td>12%</td>
</tr>
<tr>
<td>51 – 75%</td>
<td>28</td>
<td>12%</td>
</tr>
<tr>
<td>76 – 100%</td>
<td>71</td>
<td>30%</td>
</tr>
</tbody>
</table>

Table 32. Contingency Table - Percentage of Skeletal Remains Recovered for Analysis – Unresolved and Resolved Cases

<table>
<thead>
<tr>
<th>Percent Recovered</th>
<th>Resolved Cases</th>
<th>Unresolved Cases</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 25%</td>
<td>17</td>
<td>128</td>
<td>145</td>
</tr>
<tr>
<td>26 – 50%</td>
<td>14</td>
<td>32</td>
<td>46</td>
</tr>
<tr>
<td>51 – 75%</td>
<td>21</td>
<td>31</td>
<td>52</td>
</tr>
<tr>
<td>76 – 100%</td>
<td>152</td>
<td>93</td>
<td>245</td>
</tr>
<tr>
<td>Total</td>
<td>204</td>
<td>284</td>
<td>488</td>
</tr>
</tbody>
</table>
The chi-square analysis indicates that the differences in the percentage of total skeletal remains available for analysis among resolved and unresolved cases for all sample locations is significant, (p < 0.05).

Summary of Results

1) In resolved skeletal cases, postmortem anthropological findings show high levels of accuracy for all components of the biological profile, albeit at varying degrees. Estimations of biological sex had the highest rate of accuracy at 100% followed by ancestry estimations at 99%, and age estimations at 92%. Stature estimations revealed the lowest rate of accuracy at 73%.

2) Stature estimates are the least accurate component of the biological profile in resolved cases; however, this could be a reflection of missing data, as living statures were often not recorded with the antemortem data.

3) Individuals with phenotypes that do not conform to standards outlined by current methods (those developed primarily from black and white individuals) are often described using the terms admixture or listed with two or more potential ancestries.

4) FORDISC was accurate in 68% of the identified cases where it was used. Among the incorrect ancestry assessments by FORDISC, 99%
included inaccuracies related to the Hispanic category, indicating that the Hispanic parental population in FORDISC does not accurately represent the breadth of variation in the Hispanic population among these forensic cases.

5) The percentage and type of skeletal elements available for analysis is directly related to the potential for identification. A significant difference was found in the percentage of skeletal remains available for analysis among resolved and unresolved cases. The discrepancies are evidenced by the fact that more than half the skeleton was present in 85% of the resolved cases compared only to 44% of unresolved cases. Further, only 4% of the resolved cases were missing the skull versus 15% of the unresolved cases were missing the skull. Less than 1% of the resolved cases were only represented by the skull, whereas, 27% of the unresolved cases were represented by the skull only.

6) The majority of unresolved skeletal cases in Pima County are estimated to be undocumented border crossers, where investigators are hindered by limited antemortem information. Context and experience is essential to accurately evaluate the biological profile in these cases, particularly given their overwhelming misclassification by FORDISC.
CHAPTER EIGHT

DISCUSSION AND CONCLUSIONS

There is a great deal of accuracy within the biological profile developed for identification in medical examiners’ offices, particularly for resolved cases. However, methodological and interpretive variations in the assessment of stature warrant further discussion. This chapter discusses the accuracy of different components of the biological profile as reflected in the research expectations presented in chapter five. This is the first study to consider the applicability and accuracy of individual forensic methods contributing to a biological profile in medical examiner casework. These observations are a novel contribution to forensic anthropological research directly applicable to casework.

The results of this study contribute to the literature on experimental validation studies of forensic anthropological methods through the analysis of forensic case reports. However, the relationship between the methods used to construct biological profiles and the successful resolution of skeletal cases is not causal, as many factors influence such events. The findings presented here are intended as a first step in identifying the strengths and limitations associated with the application of forensic anthropological techniques, developed from limited skeletal reference populations, to the biologically diverse U.S. population in the medicolegal context.
Reviewing the Research Expectations and Aims of the Study

The central questions addressed by this research are whether the individual components of the biological profile are accurate when applied to forensic anthropology casework and which components of the biological profile are most problematic. Forensic anthropological case reports were analyzed to investigate the degree of accuracy between the postmortem description of the skeletal remains of resolved cases and the antemortem descriptions of the decedents.

Additionally, given the limited skeletal populations used to establish the various methodologies of the biological profile, and the diversity of the U.S. population as represented in the most recent census, do forensic anthropologists have appropriate tools to capture the extent of human biological variation in forensic casework to construct accurate biological profiles? These questions were investigated through the analysis of the accuracy of each component of the biological profile, the application of the statistical program FORDISC, and the disparities between resolved and unresolved cases. Central to these questions is the variation established in the scientific literature about the accuracy of forensic anthropological methods when tested on numerous population groups (see: Hartnet, 2010; Saunders et al., 1992; Murray and Murray, 1991; Martrille et al., 2007; Berg, 2008; Kimmerle et al., 2008; Fleischman, 2013; Heuze and Cardoso, 2008; Hens et al., 2008; Williams and Rogers, 2006; Rogers and Saunders, 1994; Rogers, 2005; Ramsthaler et al., 2007; Pritchard, 2007; Kemkes-Grottenhaler, 2005; Ubelaker and Volk, 2002; Ubelaker, 2009; Kosiba, 2000; Hughes et al., 2001; Urbanova et al., 2014; Guyomarc’h and Bruzer, 2011; Belcher et al., 2012; Trotter and
Gleser, 1958; Bedford et al., 1993) and also in the theoretical literature (see: Albanese and Saunders, 2007; Iscan, 1988; Montagu, 1942; Brace, 2005; Smedley, 2007; Smedley and Smedley, 2012; Wade, 1993, 1998; Tishkoff and Kidd, 2004; Livingstone, 1964, Lewonton 1972). The results of this study reinforce the interpretative nature of forensic anthropological methods and their application to forensic case work, along with the strengths and limitations of these methods in evaluating human biological variation to identify a single individual.

**Discussion of Results**

The accuracy of different components comprising the biological profile as conveyed in forensic case reports was evaluated by comparing of the forensic findings to the decedent’s antemortem information. This research provides the forensic anthropology community with valuable information regarding the applicability of certain established forensic methods in practice compared to the methods’ controlled validation studies. The following section discusses the results of this study and their implications following the four proposed hypotheses.

**Expectation One:** Among resolved cases, ancestry estimation will have a lower rate of accuracy than sex, age, and stature. The difficulties associated with estimating biological ancestry based on trait expression and using the results to assign social race categories will manifest in casework.
The results fail to support Expectation 1. Overall the components of the biological profile among resolved cases were highly accurate with estimations of stature demonstrating the lowest rates of accuracy. However, evaluation of the accuracy of stature estimations among resolved cases was precluded by the lack of antemortem stature information. The following section first discusses sex, age, and ancestry before addressing stature.

**Sex**

Among identified individuals, biological sex estimations were accurate in 100% of cases. These results exceed the statistical validation provided by studies of individual sex estimation methods of the pelvis and skull varying from 83% - 95% accuracy (Krogman, 1962; Phenice, 1969; Lovell, 1989; Sutherland and Suchey, 1991; Ubelaker and Volk, 2002; Walker, 2008; France, 1998; Giles and Elliot, 1963; Klales, 2012). It is important to consider that validation studies evaluate the accuracy of a particular forensic method on a sample group. However, in forensic practice, multiple forensic methods are employed to collect as much information as possible to accurately estimate the sex of a single set of skeletal remains. It is shown thorough this research that sex estimations are accurate in all resolved cases examined.

In addition, due to the availability of amelogenin testing, the accuracy of sex estimation could be compared to biological sex for many unresolved cases. Amelogenin results confirm 100% accuracy in New York City and Harris County sex estimations for the unresolved cases examined in this research. In Pima County, sex
estimation among unresolved cases was also accurate, but did not reach 100%. Amelogenin results confirmed that 6 cases, or 3%, had an incorrect sex assessment in the anthropological report. All incorrect assessments represent presumptive undocumented border crossers. The populations represented by the UBCs from Pima Country are described as typically displaying decreased sexual dimorphism compared to American white and black individuals, thus, their biological sex is more difficult to discern. However, in 2 of these 6 cases, FORDISC was able to accurately classify the sex of the individual.

Overall, sex estimation methods applied to forensic casework, whether in resolved or unresolved cases, resulted in accurate sex assessment; even when skeletons were missing important diagnostic skeletal elements. However, reduced accuracy rate among presumptive UBC skeletons in Pima County supports the growing body of research demonstrating the reduced power of anthropological methods on Hispanic groups (Spradley et al., 2008). This is likely because the term Hispanic is generic but the group it describes is heterogeneous.

Lastly, the pelvis and skull were almost exclusively used in the evaluation of sex. Only in cases where the skull and pelvis were unavailable for analysis did the forensic anthropologist make note of postcranial measurements for sex estimation in the case report. Recall from the discussion of sex estimation methods in chapter two that Spradley et al. (2011) found that sex estimation of the postcranial skeleton was more accurate than the skull. This evaluation is not to imply that postcranial measurements
are not taken, rather the results of postcranial sex estimation, if assessed, are often not reported in the final report.

Age

Age estimations documented in resolved case reports were 92% accurate. These results exceed statistical validation studies of age estimation methods because, like sex estimation, age estimation is rarely based on a single method. As recommended by the SWGANTH, multiple age estimation methods are applied when assessing skeletal remains. Epiphyseal fusion and dental eruption patterns were used in the analysis of juvenile remains while evidence of skeletal degeneration and bone quality were noted in adult cases. Specifically, Suchey-Brooks (Suchey, 1979; Katz and Suchey, 1986; Suchey et al., 1986; Suchey et al, 1988; Katz and Suchey, 1989; Brooks and Suchey, 1990; Suchey and Katz, 1998) was the most widely applied age estimation method, followed by sternal rib end analysis (Iscan et al., 1984a; Iscan et al., 1984b; Iscan et al., 1985; Iscan and Loth, 1986; Iscan et al., 1987). Evaluation of the auricular surface of the ilium (Lovejoy et al., 1985; Buckberry and Chamberlain, 2002; Osborne et al., 2004) was also applied, but when used in conjunction with Suchey-Brooks, estimations typically favored the range provided by the pubic symphysis. This preferential bias may suggest that anthropologists place more confidence in the analysis of the pubic symphysis when evaluating the pelvis. Similarly, cases represented by the skull only, in which cranial suture closure methods were applied (Meindl and Lovejoy, 1985; Nawrocki, 1998), age estimations were reported as large
numerical age ranges or by statements describing the sutures. For example, an
individual with obliterated sutures would be “consistent with an older adult.” If this
person were an older adult, the estimation is accurate. In contrast to the reports from
NYC or Pima County, cranial suture analysis was always applied in Harris Country if the
skull was available for analysis – even when postcranial remains were present. Cranial
sutures are rarely used in NYC, even in cases consisting of only a skull. When they are
used, general statements such as “consistent with older adult” characterize the
individual. In Pima County, the transverse palatine suture is sometimes used, and the
post doctorate employees may use cranial suture scoring outlined in Standards
(Buikstra and Ubelaker, 1994), but ultimately, it is up to the discretion of the individual
analyst (Bruce Anderson, personal communication). These findings support Garvin and
Passalacqua (2012), whose research determined that the pubic symphysis, followed by
the sternal rib ends are the most commonly preferred age estimation methods among
forensic anthropologists while cranial suture closures are least preferred.

The results of the present study are consistent with previous research indicating
that skeletal age estimation for younger individuals is more precise than estimations on
skeletal remains from older individuals (Komar, 2003; Berg, 2008). Recall that age
estimation methods evaluate the progression of growth and development in young
individuals contrasted with the progression of degenerative processes in older
individuals. Growth and development is genetically constrained and can be accurately
predicted by current methods, however, degenerative processes are affected by a
number of environmental and genetic constraints thus, reducing the precision of adult
age estimations (Berg, 2008). The present study also supports research indicating that estimated age ranges for skeletons representing younger individuals are narrower than the age ranges assigned to older individuals. Akin to the uncertain language describing ancestry in unidentified cases, instances where limited skeletal material was available for age analysis, revealed vague terminology such as, “adult,” “young adult,” “middle-aged adult,” or “older adult” to describe the decedent. These terms are highly ambiguous and limited in their interpretive value, contributing little to an investigation.

Despite the large number of age estimation methods available to practitioners, only a small number of them are actually used in casework. There are several possible explanations for this finding: (1) anthropologists apply the methods in which they are most familiar and comfortable, the ones they use are all older, tried and true – nothing after 2002 (Buckberry and Chamberlain, 2002). (2) Full time forensic anthropologists are not trained to use newer methods. For example, transition analysis performs well in validation studies (Milner and Boldsen, 2012) and has been included in the University of Tennessee’s revised Data Collection Procedures manual (2016), but is not used in any of the three offices analyzed for this study. Additional examples include Klales et al. (2012) method for sex estimation and the Hartnett (2010) method for pubic symphyseal aging. These methods revise older methods and have demonstrated increased accuracy, stronger statistics, and additional reference samples. (3) Medical Examiner cases may be tried in court. Therefore forensic anthropologists rely on common methods that have reached the level of “general acceptance” in the field. This may be
an attitudinal barrier to the implementation of new methods primarily due to the Daubert ruling.

In sum, reports on age estimations among resolved cases illustrate a high level of accuracy, most likely attributable to the application of multiple methods for estimating skeletal age at death.

Stature

In resolved case reports where stature calculations could be performed and antemortem information was available for comparison, stature estimations were accurate in 73% of cases. The majority of inaccurate stature estimations were observed in the undocumented border crosser population at the Pima County Office of the Medical Examiner. This is lower than the rate of accuracy for ancestry estimations providing the reason why expectation one is not supported. The low rate of accuracy among stature estimations in the Hispanic population can be explained by (1) the lack of stature data from Hispanic skeletal reference collections, (2) Pima County’s regular use of Sjovold (1990) rather than FORDISC 3.0 stature regression formula for the Hispanic population, (3) incorrect antemortem stature information for reasons outlined in chapter two, and (4) the large amount of missing antemortem stature data available for analysis.

Ancestry

This section directly addresses research expectation one with a thorough examination of the accuracy of ancestry estimation methods in forensic casework.
Among resolved cases examined for this study, ancestry estimation was accurate 99% of the time, thus failing to support the research expectation. To achieve this level of accuracy, anthropologists applied a combination of non-metric trait analyses as well as metric analyses using FORDISC. Non-metric traits detailed by Krogman (1962), Rhine (1990), and Gill (1998) are employed in all cases containing skulls. These morphoscopic trait characteristics are outlined in most forensic anthropology textbooks providing a summarized list for anthropologists to examine during analysis. Chapter two (Table 3) detailed the small sample sizes used to develop the population specific trait lists commonly used in ancestry assessment. As discussed in chapter’s two and three, sample groups do not adequately represent the variation observed in the current U.S. census populations (Hefner, 2014). The described mixture or blending of morphological traits observed in forensic casework does not automatically mean an individual is of admixed decent, rather it may indicate that the individual displays a phenotype not represented in the applied methods (Hefner, 2009; Hughes et al., 2011).

Despite these considerations, the results of this study show that ancestry estimation correlated with antemortem racial categories even when the skeletal remains exhibited a mixture of traits attributed to different biological groups. Despite the numerous challenges in estimating ancestry to infer race, the results of this study show that current methods perform well in the medicolegal system. The inclusion of multiple ancestries in the final anthropological estimation of ancestry to describe the biological traits of unknown individuals is an effective technique employed by forensic anthropologists. This technique was regularly utilized in all three offices ensuring that
unknowns are not unintentionally excluded from potential matches to missing persons. Terminology such as “black/white admixture” and “white or Hispanic” was employed to convey the morphological variation observed among the resolved cases. However, using multiple ancestries to describe the decedent can be interpreted as uncertainty or hedging bets. The results of this study, conversely, suggest that morphological and metric analyses are able to detect population-level human biological variation. Regardless of the interpretation of these results, the decision to report population level variation serves to appropriately describe the individual, thus leading to a high rate of accuracy. This research identifies a disconnect between the reporting of race in missing persons cases and the scientific assessment of ancestry. Despite the accuracy observed by the results of this study, greater precision can be achieved through changes in the missing persons reporting process.

An effort to increase precision in ancestry assessment is not new. Recent studies have been developed to address the frequency at which non-metric traits occur in all populations. Hefner (2009) evaluated the frequency of ancestral traits in white, black, and Hispanic groups and developed a method based on discriminant functions to distinguish between these three populations. However, the study does not provide the discriminant function equations for anthropologists to apply in casework and rarely if ever has an anthropologist been confronted with skeletonized remains known to be either a white, black or Hispanic individual. Additionally, Hefner (2009) is not used to estimate ancestry in these medical examiners’ offices. Furthermore, Hefner (2014) outlines the Optimized Summed Scored Attributes method (OSSA) in which six
morphoscopic traits are scored following Hefner’s (2009) guidelines. Unfortunately, this method is designed to maximize the differences between black and white individuals only and was not cited in the case reports analyzed for this study because the method was not published at the time of data collection. Studies like these should be expanded as they may help forensic anthropologists to discern population level variation and continue to improve ancestry estimation among individuals with recent admixture.

**FORDISC**

FORDISC results fared poorly among the resolved cases showing accuracy in only 46 (32%) of cases. In general, FORDISC performed well for individuals of African, European, and Asian ancestry. However, FORDISC was consistently unable to accurately predict the ancestry of individuals within purported Hispanic population groups. This phenomenon was documented in all three medical examiners’ offices. However, undocumented border crossers make up the majority of unknown skeletonized individuals in the Pima County medical examiner’s office and the majority of these individuals were incorrectly classified by FORDISC. Specifically, 20 UBCs were classified in Asian categories. During the construction of this dissertation, Dudzik and Jantz (2016) confirm these findings, demonstrating that FORDISC frequently misclassifies Hispanic crania into Asian groups, most likely due to the similar population histories of Native American and Asian individuals.
Additionally, a contingency table and chi-square analysis was conducted to evaluate whether a sex bias exists among FORDISC results. The analysis failed to show a sex bias among FORDISC results.

Further, forensic anthropologists at Pima County are aware of FORDISC’s limitations with this population and have demonstrated the ability to interpret FORDISC’s results appropriately as no ancestry estimations among the population of UBCs were published exclusively as Asian. Is it possible that persons of Vietnamese, Japanese, or Chinese descent perish along the border? Yes, however, it is unlikely (Anderson, personal communication). The discovery context and associated material evidence allows anthropologists in Pima County the ability to interpret FORDISC results not as Asian, but as some degree of Native American.

Pima County is a prime example of prior probability statistics in practice as outlined by Konigsberg et al. (2009). Further, Pima County anthropologists have implemented the terminology, Admixed Native American (ANA) to describe UBCs. This terminology is biologically and culturally appropriate for the migrant population served by the anthropologists in Pima County. The term recognizes the shared genetic history of this population (Native American, European, and African) without engendering a negative response by using the term Hispanic (Anderson, personal communication). The limitations of FORDISC to adequately identify Hispanic individuals, as demonstrated by the present study and supported by Dudzik and Jantz (2016), should be addressed. The anthropologists in Pima County are familiar with these limitations.
and have adapted methodologies to accommodate spurious FORDISC findings, but it is not known how various users interpret FORDISC.

Contrary to the purported success of FORDISC with populations present in its database (Jantz and Ousley, 2013; Freid et al., 2005; Elliott and Collard, 2009), FORDISC did not correctly classify any male or female Guatemalan individuals from the Pima County office. Table 14 displays the inaccurate FORDISC results involving the Guatemalan sample indicating cases where Guatemalans were not classified correctly by FORDISC or where non-Guatemalans were classified as Guatemalan. Given that a modern Guatemalan skeletal population derived from the Forensic Anthropology Foundation of Guatemala, is included in the FORDISC database, the question remains – why were the recovered skeletal remains of Guatemalans who died crossing the southern border of the United States not correctly classified as Guatemalans in FORDISC? The misclassifications directly contradict the results found by Spradley (2014), where she found good statistical separation of Guatemalan Mayans and Mexicans.

There are three possible explanations (1) the population of Guatemalan individuals in the FORDISC database does not represent the Guatemalan population as a whole and more specifically, those migrating to the United States. The term Guatemalan, applied generically to anyone from Guatemala, is a modern form of colonialism. The genetic and phenotypic variation between indigenous Guatemalans (Mayan decent) and individuals identifying as Mestizo (Spanish European and Amerindian decent) are significant, as illustrated by Spradley (2014). The Guatemalan
population in FORDISC represents descendants of Mayan individuals obtained from human rights contexts and provided by the Forensic Anthropology Foundation of Guatemala (Spradley et al., 2008a). (2) Measurement data from the forensic cases is not accurate. This assumption is unlikely as the majority of individuals identified as U.S. citizens were correctly assessed for ancestry. (3) Measurement data from the FORDISC Guatemalan skeletal sample is not correct. Furthermore, the accurate measurement of all individuals in FORDISC cannot be verified as data has been submitted by 100 anthropology offices and by students measuring the William M. Bass collection.

Similarly, the most recent University of Tennessee Data Collection Procedures for Forensic Skeletal Material 2.0 (2016) modified the definitions for a collection of measurements because they have shown disparities. Additionally, while most of the data in FORDISC is derived from positively identified individuals, the Hispanic category is an exception. According to Jantz and Ousley (2013), Hispanic individuals are largely contextually identified. This is also true of the historic Amerindian population. A combination of factors likely contributes to the inaccurate classification of Guatemalan skeletal remains; consequently, it is possible that these factors can also contribute to the misclassification of any unknown individual.

Further supporting the accuracy of ancestry estimations in casework is the practice of broadening ancestry estimations to incorporate FORDISC results. For example, a white individual is estimated as black by FORDISC; the anthropological case report describes the individual’s ancestry as “white and black admixture,”
“white/black,” or “white or black.” The anthropologist may have detected morphological traits consistent with both groups and FORDISC validated the morphological observations contributing to the black ancestry classification. Thus, including black in the final ancestry assessment was justified. This strategy ensures that an individual is not unintentionally excluded from the pool of possible matches. It is also possible that FORDISC is picking up population level variation that the anthropologist was unable to detect morphoscopically. Another technical application of FORDISC to casework is the users ability to select the population groups for comparison. If admixture is suspected, the analyst may select the presumed sources for comparison. Regardless, FORDISC will only provide probability statistics for the selected groups, whether they are the most appropriate or not. The anthropologist must then evaluate the probability statistics to select the most appropriate estimation. This is why it is imperative that practicing forensic anthropologists understand and appropriately interpret the probability and typicality statistics provided by the program.

Additional caveats to the application and interpretation of FORDISC in casework include: database populations (American white, American black, Hispanic, Guatemalan, Japanese, Chinese, Vietnamese, and American Indian) are not representative of the U.S. population, the FORDISC authors caution that the program can only work if the unknown in question belongs to a population represented in the database, the different population proportions present in the database are not representative of forensic casework, and the possibility that some individuals in the FORDISC database are genetically admixed, but did not self-identify as admixed in life (or maybe were not even
aware) but are classified in FORDISC as belonging to one group. Further, one of the FORDISC authors (Jantz) purports that secular change among the population is occurring. Therefore, the forensic population within FORDISC is more appropriate in modern casework (as opposed to the antiquated Hamann-Todd and Terry individuals in the database).

The FORDISC help file describes the modern population samples within and make the following notations: (1) the modern sample of American Indians contains only 15 males and 5 females with the remaining 44 males and 27 females representing 19th century Amerindian remains (Indian Knoll) “most of which were known.” If secular change is occurring, then the majority of American Indians in this dataset are not representative of modern populations. Further, this sample contains unknowns, so their ancestry is unconfirmed. (2) The African American population consists of Americans from 27 different states as well as a “good number come from the Terry collection.” Again, secular change is occurring in the African American population (Meadows and Jantz, 1995; Jantz and Jantz, 1999; Jantz and Jantz, 2000) so the inclusion of African American Samples from the Terry collection to classify modern Americans is problematic. (3) The Chinese sample consists of 79 males exclusively sourced from Hong Kong City University cadavers. This sample is not representative of all Chinese individuals and is not representative of the immigrants to the United States. According to Hooper and Batalova (2015), only 1 in 10 Chinese immigrants to the United States originated from Hong Kong. (4) The Guatemalan sample consists of 83 males. The
data from Pima County proves that Guatemalan females are included among forensic casework.

Table 33 compares the U.S. census data for NYC, Harris County, and Pima County to the forensic population within FORDISC and shows the difference between the demographics of the U.S. population compared to the sample populations referenced in FORDISC. This is not to say that that FORDISC does not have utility or is incapable of performing discriminant functions to help estimate ancestry. Rather, the program has limitations that impact the ability of the program to correctly classify unknown individuals in U.S. forensic cases.

### Table 33. 2010 Census Data and FORDISC Forensic Population

<table>
<thead>
<tr>
<th>Reported Race Category</th>
<th>NYC (2010 Census)</th>
<th>Harris County (2010 Census)</th>
<th>Pima County (2010 Census)</th>
<th>FORDISC Samples (July, 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>44%</td>
<td>70%</td>
<td>85.5%</td>
<td>46.5%</td>
</tr>
<tr>
<td>Black</td>
<td>25.5%</td>
<td>19.5%</td>
<td>4.1%</td>
<td>13.6%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>28.6%</td>
<td>41.6%</td>
<td>36.1%</td>
<td>20%</td>
</tr>
<tr>
<td>Asian</td>
<td>12.7%</td>
<td>6.8%</td>
<td>3.1%</td>
<td>15%</td>
</tr>
<tr>
<td>American Indian/Alaska Native</td>
<td>0.7%</td>
<td>1.1%</td>
<td>4.3%</td>
<td>5%</td>
</tr>
<tr>
<td>Native Hawaiian or Pacific Islander</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.2%</td>
<td>0%</td>
</tr>
<tr>
<td>2 or More Races</td>
<td>4%</td>
<td>1.7%</td>
<td>2.8%</td>
<td>0%</td>
</tr>
</tbody>
</table>
**Difficulties of Ancestry Estimation**

Another important consideration for the accuracy of ancestry estimations deals with the antemortem descriptions provided for missing persons. Not one single individual was described as having admixed ancestry in the antemortem data. While this does not mean that an individual is not ancestrally admixed, it does mean that this individual did not identify as racially admixed – and their self-identification is the foundation of antemortem information leading to identification. When a person goes missing, the reporting party files a missing persons report to law enforcement with the intention that the descriptive information is going to help find their loved one, presumably alive. The report is not designed to cater to the scientific methods of forensic anthropologists. However, the missing persons report is often used to compare against the anthropological report. Thus, the missing persons reporting process including the missing person’s report form itself is structurally flawed. The investigative body wants to know the race of the missing individual and not necessarily the biological ancestry in which anthropologists are trained to detect.

Further, the report forms from numerous jurisdictions present a series of checkboxes that imply to the reporting party that one box should be checked, although instructions do not limit the number of boxes that can be checked. Other jurisdictions allow the reporting party to fill in a blank. Thus, there are (1) social/cultural, (2) biological, (3) procedural, and (4) structural factors that limit the forensic anthropologist in their ability to accurately identify the social race category of an unknown individual despite any accurate assessment of biological ancestry.
An example of these four limitations can be observed in the hypothetical case of an individual described as Hispanic. First, social/cultural: in the U.S., the Hispanic population is recognized as a social/cultural group based on a linguistic definition of Spanish-speaking peoples (Spradley et al., 2008) although they do not always identify that way (Spradley, 2014). Second, biological: Hispanic individuals are biologically descendent from European, Native American, and African individuals in varying degrees (Hughes et al., 2013). Thus, Hispanic individuals provide examples of those who display a wide range of traits consistent with all of the above ancestral groups in varying frequencies. Third, procedural: the anthropologist utilizes ancestry estimation methods available to interpret biological cues to describe the possible geographic origins of the unknown although the methods used may not account for the variation observed. Lastly, structural: a family member or friend files the missing person’s report and tasked with identifying the race of the disappeared by marking the form accordingly. The reporting party may check one box or more boxes, but ultimately has no control of the information that is disseminated through the medicolegal system.

As observed in recent U.S. Census data, a growing number of individuals are born into multi-racial families. These individuals are considered biologically admixed and may display a variety of traits from multiple ancestries. In addition, these individuals may identify with a single racial group, more than one racial group or change their self-identification over time. Racial self-identity, as noted by Hahn et al, (1996) and M’Charek (2013), shifts through time and the structural classification of race built into the US census also shifts through time (Mather et al, 2011). In a discussion on ancestry
estimation the authors of FORDISC state, “Of course we can be wrong, because the question asked pertains to social race, but the answer provided is based on biology” (Jantz and Ousley, 2013:267). This means that anthropologists may be able to detect population level traits on skeletal remains, but they may be unable to predict how that individual’s phenotype translates into their racial self-identity.

Despite the inherent limitations presented here, the accuracy of ancestry estimations in the offices examined for this research reached 99%. The combination of morphological examination and metric analysis provided enough information to lead to an accurate assessment of ancestry among the resolved caseload.

**Expectation Two: Stature estimation, regardless of its accuracy will be uninformative.**

The results partially support Expectation Two. Stature calculations were performed when the appropriate skeletal materials were available for analysis. Stature calculations in New York City and Harris County were typically performed in FORDISC and were found to be accurate in 92% and 85% of cases, respectively. Stature estimations revealed lower accuracy rates in Pima County, at 55%. This disparity may be explained by the lack of stature information available for Hispanic individuals and the use of Sjovold (2010), which produces smaller stature ranges. However, most individuals in the Pima County dataset lack sufficient antemortem information, therefore
these results only reflect a small sampling of the total cases and should be interpreted with caution.

Overall, comparisons of stature estimations from skeletal remains to antemortem stature data are limited. One reason for the limited comparisons can be attributed to the lack of appropriate skeletal materials to conduct stature calculations (e.g. cases represented only by a skull). However, there exist methods to estimate stature from other skeletal materials such as the metatarsal (Robling and Ubelaker, 1997). Although numerous methods to calculate stature have been developed, typically methods employing the maximum lengths of long bones are used because they are widely accepted in the forensic community, easy to implement, and are population specific. Another problem with stature comparisons was encountered because the decedent’s antemortem records (medical records, dental records, missing person’s reports/flyers, newspaper clippings, death certificates) were often devoid of a recorded living stature. Further confounding the accuracy of stature estimations in forensic casework is the incorrect measurement of the decedent in life. In these instances, anthropological stature calculations may yield the correct stature estimation, but the comparative antemortem information is incorrect. As previously described in chapter two, there are differences between living stature, cadaveric stature, and estimated stature. Living stature may be intentionally or unintentionally incorrect on a driver’s license or other personal documentation. Stature can also be over- or under-estimated by family and friends filing missing persons reports, assuming height is reported at all.
Overall, the lack of antemortem stature information and the potential for inaccurate living height data suggests that stature may not be a crucial piece of information in the investigation and identification of missing persons and unknown skeletal remains. Currently, stature estimations can be useful for exclusionary purposes, or useful only to identify individuals exhibiting the extreme ends of the stature spectrum, rather than a unique piece of information. The decreased power of stature estimation found in this study is contrary to previous research claims that stature is a vital component of the biological profile (Wilson et al., 2010, Cardoso et al., 2016). Regardless, the results of the present study do not support the abandonment of stature estimation. Instead, the results identify a need for adequate sample sizes of all population groups, population specific stature estimation formulae, and effective dissemination of data among law enforcement, death investigators, and the anthropological community.

Expectation Three: Unresolved cases will exhibit logistical challenges that hinder the anthropological evaluation of the biological profile.

The unresolved caseload analyzed for this study consisted of 284 cases from the three study locations. The cases persist as unresolved for a variety of reasons including but not limited to (1) the decedent is not known to be missing or has not been reported to the authorities as missing, (2) the biological evidence (DNA, biological profile) has yet to support an identification, (3) the decedent was discovered in another
area of the country and jurisdictional and law enforcement constraints have prevented a match, and (4) the decedent is an undocumented border crosser. Although there is no way of knowing exactly why an individual persists as unidentified, the analysis of the anthropological case report can provide valuable information.

A significant finding among the unresolved cases is the amount of skeletal remains available for anthropological analysis. The results show that unresolved cases have fewer skeletal elements available for examination compared to the resolved cases. The majority of resolved cases were comprised of 50% or more of the skeleton compared to less than half of the unidentified cases represented by 50% or more of the skeleton. Essentially, the populations of unidentified cases are missing significant portions of skeletal elements. For example, 27% of the unidentified individuals are only represented by a skull, compared to less than 1% of identified individuals with the only a skull. Results such as 15% of unresolved lack a skull, compared to only 4% of resolved cases being devoid of a skull. Additionally, the difference between the amount of skeletal remains available for analysis among resolved and unresolved cases was found to be significant. These results indicate that there are significantly more cases representing larger proportions of skeletal remains among resolved cases compared to unresolved cases. This is important because a variety of information can be gleaned from an abundance of skeletal evidence. When fewer elements are available for analysis, there is potential for loss of information. These findings are consistent with the research conducted by Komar and Potter (2007). The authors conclude that there is a correlation between the percent of recovered body and identification rates. They found
89% of complete bodies were identified while only 56% were identified when less than half of the body was present. Also similar to the present research, Komar and Potter (2007) concluded that the absence of a skull negatively affects identification rates.

Standards for Evidence and Expert Witness Testimony

Ancillary to the hypotheses posed in this research is whether the anthropological methods, used to establish a biological profile in forensic case work, meet the expectations imposed by the court ruling following Daubert vs. Merrill Dow Pharmaceuticals Inc. and further implored by the 2009 NAS Report. Unlike fields colloquially referred to as hard sciences, such as DNA, toxicology, chemistry or physics, in which statistical probabilities and reported error rates are typical, forensic anthropology is still in the process of developing such quantitative rigor. Forensic professionals in the hard sciences have the ability to conduct empirical studies and maintain objectivity when conducting analyses. Conversely, methods currently applied in forensic anthropological analyses rely on mutable evidence requiring interpretation and experience.

In a valiant effort to strengthen forensic anthropological methods, researchers have forced empiricist methods on biological realities. The present research supports the notions that there is no universally applicable gold-standard for which anthropological methods can be practiced. Anthropologists can and must acknowledge the strengths and weaknesses of our forensic methods and strive to consistently apply
the rigor proposed by Steadman et al., (2006). Few cases reviewed for this study conformed to these standards. In fact, not one case documented likelihood ratios for the presumed identification.

This level of rigor would require the anthropologist to use Bayesian statistics indicating the likelihood of the identification compared to a known prior. Currently Bayesian methods are not utilized by forensic anthropologists conducting casework and therefore are not on the path to general acceptance. Additionally, anthropology labs should develop standard operating procedures (SOPs) to ensure consistent and appropriate application of methods. Of the three labs analyzed for this analysis, only the Harris County Institute of Forensic Sciences has standard operating procedures in place. Additionally, the Harris County Institute of Forensic Science received ASCLD/LAB certification during the construction of this dissertation. The anthropology labs in NYC and Pima County are working toward implementing standard operating procedures.

Finally, the SWGANTH recommendations provide a solid foundation for forensic anthropological reference and the current study does not question their application in casework. However, this research provides evidence that a one size fits all philosophy to forensic anthropological practice is detrimental. Instead, it is recommended that anthropologists continue to pursue quantifiable scientific rigor in every case report, include error rates and likelihood ratios, and adapt anthropological methods to meet the specific populations they serve.
Why Unknowns Are Not Identified and Limitations to the Current Study

As discussed in chapter two, there are many reasons why unidentified individuals persist in casework. Persistent unidentified individuals may never have been reported missing, may not have anyone looking for them, have families that lack access to resources, or have circumstances that prohibit identification through current scientific methods. While it is beyond the scope of this study to identify all the reasons why unresolved cases persist, this research can inform the scientific community of the parameters limiting the application of different forensic anthropological methods in practice. For resolved cases, current methods used to estimate the biological profile were found to correlate well with the antemortem description of the individual.

Unfortunately, a limiting factor of this research is that there is no way to evaluate the accuracy of the methods for the unresolved cases, so we do not know if the methods are similarly working for these individuals. Another limitation of this study is that there exist numerous factors influencing the interpretation of skeletal traits that cannot all be evaluated through secondary data analysis. However, while individual interpretive decisions made by forensic anthropologists cannot be evaluated, results of their decisions can be quantified though the analysis of anthropological case reports as demonstrated by the present study. Additionally, the selection criterion for data is limited to skeletal forensic cases in the medical examiners’ offices in New York City, Harris County, and Pima County. However, the examination of case reports from these
three geographically diverse regions, at the very least, provides a first step towards understanding the applicability of anthropological methods in practice.

Future Directions

This study is the first to evaluate the accuracy of forensic methods in casework conducted in medical examiners’ offices in the United States. Ideally, the results further our understanding of how the biological profile performs in casework and can use the information to develop new forensic methods and validation procedures. Areas of weakness highlighted by this research prove a reduced power of anthropological methods in instances where fewer skeletal elements are available for analysis. This research also emphasized the limitations stature estimation and age estimation of older individuals, both supported in academic literature. While many of these limitations are partially attributed to our current lack of appropriate skeletal materials to develop forensic methods, a more profound and systemic problem is the dearth of demand to include the recommendations of Steadman et al. (2006) in more forensic case reports.

Future studies can build upon this research through the analysis of anthropological case reports in a variety of sample locations. Additionally, case reports in smaller medical examiners’ offices or offices that employ one anthropologist, part-time anthropologists, or anthropology consultants (typically full-time academics) can provide a balanced comparison. Studies like these may discover differences in the type of casework confronting these anthropologists, or differences in the accuracy of their
reports as compared to large urban medical examiner’s offices. An expanded sample population including juveniles will facilitate a comparison of the challenges and accuracy of the forensic methods applied to immature remains and the identification rate of individuals in this subcategory.

Conclusions

This research is an initial study evaluating the accuracy of current biological profile methods reported in forensic casework among anthropological practitioners in medical examiners’ offices. The results of this study provide a snapshot of both resolved and unresolved casework. The goal of the study was to discover how well the biological profile corresponded with antemortem descriptions among resolved cases and what trends could be observed in unresolved cases that may contribute to the vast numbers of unresolved cases.

The results suggest that the estimation of sex, ancestry, and age were highly accurate in the cases examined, while stature estimations were the least accurate. Strengths and limitations of anthropological methods within the framework of the medicolegal system were investigated. Additionally, this study highlights the ability of forensic anthropologists to successfully interpret biological ancestry cues for the purposes of assigning a social race category. The high rate of accuracy observed by the current study is an important finding as there are many factors that serve to complicate and obstruct the accurate assessment of ancestry. Regardless,
improvements can always be made. The missing persons reporting process should be changed to accommodate ancestral histories of the decedent and concerned parties (law enforcement, death investigators) should be trained on basic anthropological terminology.

Finally, stature estimations produced the lowest rate of accuracy of all the components of the biological profile. This is likely due to inaccurate reporting of the living height of the missing individual or because the sample size was compromised by a lack of antemortem data from which to compare stature estimations. The lack of antemortem stature information reported to the medical examiners’ offices suggests that stature was not an important factor contributing to the identification of the individual. These findings conclude that stature is currently largely uninformative in making identifications and methods need to be improved, particularly for non-whites and non-blacks. Improving methods and increasing sample populations with appropriate regression formulae will result in more accurate stature estimations and may improve the informative value of stature in investigations.

Although the accuracy of the biological profile cannot be evaluated among unresolved cases, an important finding was observed. This study found a significant difference between the percentages of skeletal remains available for analysis among resolved and unresolved cases. This finding supports previous research showing that resolved cases tend to consist of more skeletal elements than unresolved cases. These results provide support for the inclusion of a forensic anthropologist at deposition sites.
to ensure that as many skeletal remains as possible are collected, handled carefully, and accounted for.

Ultimately, many factors influence the resolution of missing persons cases. Given that approximately 40,000 sets of unidentified human remains occupy medical examiners’ offices in the United States, studies like this can help identify areas within anthropological practice and the larger medicolegal system requiring attention and refinement for the goal of increasing identification rates of the unknown.
LIST OF REFERENCES


Bidmos MA, Dayal MR. 2004. Further evidence to show population specificity of discriminant function equations for sex determination using the talus of South


Boas F. 1940. Race, Language and Culture, New York: Macmillian


http://www.migrationpolicy.org/article/chinese-immigrants-united-states


Press 48-72.


Lovell NC. 1989. Test of Phenice’s Technique for Determining Sex from the Os Pubis. 
American Journal of Physical Anthropology 79:117-120.

Human Biology 54(3):539–552.

Lyons T. 1997. Frye, Daubert and Where Do We Go From Here?. Rhode Island Bar Journal.


National Crime Information Center. 2015. NCIC Active/Expired Missing and Unidentified Analysis Reports.


Royal CDM, Dunston GM. 2004. Changing the Paradigm From ‘Race’ to Human


Smithsonian National Museum of Natural History. http://anthropology.si.edu/cm/terry.htm


http://lib.post.ca.gov/Publications/Missing_Persons_Forms/mp_report.pdf,
VITA

Hillary Parsons was born in Hudson, New York to parents Elizabeth Ann Montaneli and Robert Charles Parsons, she has two brothers: Ryan Anthony Parsons and Shane Bradford Parsons. In 1988, her family moved to Bozeman, Montana where she was able to live a life full of outdoor adventures. Hillary graduated with a Bachelors of Science in Anthropology from Montana State University, Bozeman in 2003 and received her Masters of Arts from the University of Montana, Missoula in 2009. She continued her graduate education at the University of Tennessee in Knoxville, and received her Ph.D. in May of 2017. During her time at UT, Hillary was a graduate teaching assistant in introductory biology and human anatomy. History Flight Inc., a non-governmental organization that locates and recovers missing U.S. servicemen from wars of the 20th century, currently employs her. She regularly deploys to Tarawa, Kiribati to locate and recover America’s missing war heroes.