



Second Edition

Hard Evidence

Case Studies in Forensic Anthropology

Dawnie Wolfe Steadman

S E C O N D E D I T I O N

HARD EVIDENCE

CASE STUDIES IN FORENSIC ANTHROPOLOGY

Edited By

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*To my grandparents, who have
taught me the value of education,
the merit of service, and
the importance of family*

*And to my husband, Gary,
who helps me teach these
qualities to our sons*

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PREFACE

The first edition of *Hard Evidence* was born from a need for scientific realism in the face of media popularization of the field whereby the aptitude of forensic anthropologists for solving forensic cases borders on mythic or even science fiction. The heart of forensic anthropology is the adherence to the principles of skeletal biology and rigorous attention to detail in lieu of a hologram machine or psychic powers. The goal of the first edition was to provide case studies that demonstrated the scientific approach and techniques of forensic anthropology in a manner that was both accessible and interesting. That goal was met thanks to the brilliant authors that contributed to the volume. The goals of the second edition are not unlike those of the first—to supplement the burgeoning number of forensic anthropological textbooks with case studies that demonstrate a number of scientific principles. However, this edition improves on the first in a number of ways, including more cases on topical areas of inquiry (e.g., child abuse, forensic archaeology), important scientific techniques (e.g., facial reproduction, DNA), and legal issues, as well as updates of existing cases. In all, seven new chapters are included, six chapters are updated, and the utility of the text is increased by an index.

NEW CONTRIBUTIONS TO THE SECOND EDITION

As the first edition was being written, significant events impacted the world and the discipline of forensic anthropology. Over thirty anthropologists participated in the recovery and identification efforts in the months after September 11, 2001. Amy Zelson Mundorff, one of the contributors to the first edition, was the forensic anthropologist for the Office of the Chief Medical Examiner (OCME) in New York City and helped coordinate the identification efforts for the World Trade Center disaster. While Amy and I discussed including a chapter about the response in the first edition, the timing was not right. Not only did the events seem too “fresh” to write about, but I really wanted to include the anthropological perspectives from the responses at the other sites. Thus, this edition includes a contextual overview of the anthropological roles in the responses to the World Trade Center, Pentagon, and Shanksville, Pennsylvania, disasters. Paul Sledzik took on the unenviable tasks of coordinating authors and braving multiple bureaucratic agencies to make this chapter come to fruition and I am in his debt.

Increased legal adherence to *Daubert* and other rules of evidence has stimulated much anthropological research in the past five years. In the first edition, Lyle Konigsberg and I lamented in “Multiple Points of Similarity” that quantifying the strength of a positive identification is extremely challenging with standard osteological data of age, sex, stature, and pathology. This chapter became fodder for a larger study of the quantification of osteological congruency in potential identifications (Steadman, Adams, and Konigsberg 2006) and is now updated to include these new results. In addition, Wieserma and Love present a new radiographic technique that also permits quantification of the strength of an identification. While the statistics may initially appear daunting, the principles are not difficult to comprehend and a quantified approach is crucial to anthropologists who present their reports in court.

Other additions to this edition not only reflect the strengths of the former edition in presenting accessible case studies but expand the scope to include a broader number of anthropological contributions to forensic science. The inclusion of a chapter on child abuse is particularly pertinent and timely. Given the increase in the number of cases of child abuse/fatalities, it is imperative that forensic anthropologists recognize the skeletal signature of intentionally inflicted injuries. Douglas Ubelaker provides an in-depth

examination of the three primary techniques of forensic facial reproduction as well a historical perspective of the field.

ORGANIZATION OF THE SECOND EDITION

The organization of the book has changed to reflect new and different emphases than the first edition and one additional section is provided. The case studies in Section I focus on different aspects of personal identification, from the particular methods used to the impact on the families when the truth about the fate of a loved one is finally known. Section II emphasizes the legal context in which forensic anthropologists must operate. Recent legislative changes concerning the rules of evidence admissibility greatly impact how anthropologists present their findings in court, which is further demonstrated by two new chapters. In addition to the Wiersema and Love chapter that discusses rules of evidence, Ousley and Hollinger discuss the laws governing historic cases, particularly those involving Native American remains. Stephen Ousley is one of the original architects of Fordisc and provides an expanded example of its use within historic contexts.

Section III focuses on archaeological applications of anthropological casework. In addition to two domestic cases, including an interesting update on a case presented by Sauer and colleagues, this section further highlights the efforts of the anthropologists at the Joint POW/MIA Accounting Command-Central Identification Laboratory (formerly known as CILHI). Mann and colleagues present some new data in their discussion of two cases from Vietnam while a novel chapter by James Pokines reviews the importance of taphonomic influences in archaeological recoveries. This discussion of taphonomy leads into Section IV, Interpretation of Taphonomy and Trauma. Marks and co-authors add to the casework on trauma by providing a rich perspective on the skeletal markers and interpretation of child abuse, while Marks and Love, together with Ian Dadour provide additional information on forensic entomology.

Section V, Analytical Techniques in Forensic Anthropology, includes cases that employ DNA, skeletal histology, bone chemistry, and cut mark interpretations. This section is bolstered by the new chapter on facial reproduction by Ubelaker. Section VI, Mass Disasters and Human Rights Investigations, contains the final chapters of the book. Sledzik provides some updates in the chapter on the first DMORT deployment while multiple anthropologists, led by Sledzik, discuss the largest mass disaster response in the United States—that of September 11. The human rights component is strengthened by another contribution by the Argentine Forensic Anthropology Team (EAAF), which provides some additional perspectives on the investigations of the Dirty War in Argentina.

ACKNOWLEDGMENTS

In addition to the all of the people who helped me write the first edition, I'd like to thank Nicole Jastremski for helping to copy edit the updated section overviews. I am also thankful to my editor, Nancy Roberts, who kept pushing me to do a second edition and didn't take my response of "Over my dead body!" too literally. I again want to recognize my husband, Gary (a.k.a. "the most patient husband in the world"), whose support and humor knows no boundaries. Finally, I want to thank my two sons, Ryan and Collin, who give me perspective, balance, and more love than I ever imagined existed.

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Personal Identification: Theory and Applications

The Case Study Approach

In the summer of 1990, four male friends entered an abandoned farmhouse in Iowa, but only three emerged alive. While one stood watch outside, two of the men shot their friend multiple times and threw his body into a well behind the farmhouse. It remained there until it was recovered nearly a decade later. Could the last moments of his life be interpreted from his mangled bones? In another part of the Midwest, an incomplete, disarticulated female skeleton was found scattered along a riverbank. Two women of the same age, height, and ancestry were missing from the area. How could experts determine whether the handful of bones belonged to one woman or the other? Could this also be a case of foul play?

No matter in what morose scenario unknown human remains are recovered, every jurisdiction in the United States has statutes requiring a medicolegal investigation of the identity of the individual and the circumstances of his or her death. By virtue of their expertise in skeletal biology, forensic anthropologists may be called upon by law enforcement agencies, coroners, medical examiners, and forensic pathologists to assist in the recovery of human remains, conduct skeletal analyses for the purposes of identification, describe the nature and extent of skeletal trauma, and potentially provide expert testimony in a court of law. Forensic anthropological services are typically requested when human remains are decomposed, burnt, fragmentary, cremated, dismembered, fully skeletonized, or otherwise unidentifiable by visual means. Scenarios in which a forensic anthropologist may consult include burials, structural fires, explosions such as the Oklahoma City bombing, mass graves, commercial and clandestine cremations, and mass fatality incidents. The most recent examples of large-scale forensic anthropological involvement are the recovery of victims of Hurricane Katrina and the identification of victims killed in the terrorist attacks of September 11, 2001 (see Chapter 23). Increasingly, forensic anthropologists are also expanding their purview beyond the local landscape and working around the globe to identify soldiers missing in action and the victims of wars, human rights atrocities, and mass disasters, such as the Asian tsunami of 2004.

Forensic anthropology is best defined as the application of anthropological and skeletal biological principles to medicolegal issues. The term *medicolegal* refers to the capability of medical science to shed light on legal matters, such as the identity of the deceased and the circumstances of death (Fisher 2000). Skeletal biology is the study of the human skeleton

and encompasses several subdisciplines, including forensic anthropology and bioarchaeology, the study of past population behavior, health, and disease. Bioarchaeology adopts a population-oriented approach and typically involves the examination of human remains and artifacts from an entire historic or prehistoric cemetery. While forensic anthropologists typically analyze only one or a few individuals at a time, they must also be knowledgeable about the entire range of human variation. In fact, by virtue of their casework, forensic anthropologists directly contribute to our understanding of skeletal diversity among contemporary populations (Ousley and Jantz 2005; Ubelaker 2000).

Forensic anthropological involvement in the medicolegal community begins with, and is based upon, an exhaustive case report including, as appropriate, documentation of the methods of identification, an accurate reconstruction of trauma that occurs at or around the time of death (perimortem trauma) as well as after death (postmortem trauma), and an estimate of the postmortem interval, or time since death. If a case goes to trial, this report becomes the core of the forensic anthropologist's testimony. Once there is legal resolution, forensic anthropologists can publish a case study in order to share important new information or techniques with students and colleagues. With this in mind, the purpose of this volume is to utilize case studies to demonstrate the appropriate techniques, ethical responsibilities, and training involved in the practice of forensic anthropology in the United States today. The contributing authors provide comprehensive coverage of one or more cases, demonstrate the forensic methods utilized to resolve the case, and, when appropriate, offer personal insight about mistakes, pitfalls, and ethical issues related to their experiences. Ultimately, the case studies in this volume illustrate three principal themes—the roles and methods of modern forensic anthropology in local and international casework, the well-developed scientific methodology upon which forensic anthropological techniques are founded, and the multidisciplinary nature of forensic science.

PROFESSIONALISM AND TRAINING IN FORENSIC ANTHROPOLOGY

Although prominent anthropologists have practiced forensic anthropology since the 1920s and 1930s (see Kerley 1978; Komar and Buikstra 2008; Stewart 1979; Ubelaker 1990, 1999, 2000 for historical reviews), the profession was formalized in the United States in 1972 with the formation of the Physical Anthropology section of the American Academy of Forensic Sciences (AAFS). The AAFS is the primary professional organization of forensic science in the United States and currently consists of ten professional sections, listed below. As of this writing, there are over 300 members of the Physical Anthropology section.

- Criminalistics
- Odontology
- Questioned Documents
- Toxicology
- Jurisprudence
- Engineering
- Pathology/Biology
- Physical Anthropology
- Psychiatry and Behavioral Sciences
- General

Over the past few decades, many anthropologists have received specialized training in forensic methods in addition to their general anthropological education. This trend continues today as more and more institutions are developing formal graduate programs or

programmatic emphases in forensic anthropology. However, since relatively few anthropologists find full-time employment practicing forensic anthropology exclusively, it is imperative that students maintain broad anthropological training. That is, specializations that are unique to forensic anthropology, such as gunshot trauma analysis or facial reproduction, should enhance, not replace, an extensive education in the four fields of anthropology—linguistics, cultural anthropology, biological anthropology, and archaeology (Komar and Buikstra 2008; Ubelaker 2000). Archaeological methods are especially important in forensic anthropology, as is cultural anthropological theory, particularly in international work. A robust education in the social and biological sciences is also valuable, and should include genetics, biochemistry, anatomy, evolutionary biology, criminal justice, and statistics.

A well-grounded foundation in biological anthropology underlies the success of any professional forensic anthropology position, whether it is within or apart from academia. While most professional forensic anthropologists work in a university setting, non-academic positions also offer many opportunities for those who are broadly educated. For instance, anthropologists at the Smithsonian Institution accomplish a considerable amount of forensic work (Grisbaum and Ubelaker 2001) and also conduct research in paleopathology, bioarchaeology, and population genetics (e.g., Owsley and Jantz 1994; Verano and Ubelaker 1992). Similarly, anthropologists from the Joint POW/MIA Accounting Command-Central Identification Laboratory (JPAC-CIL) in Hawaii apply their forensic anthropological and archaeological expertise to recover and identify U.S. soldiers and civilians lost in past conflicts as well as investigate local cases. A growing number of anthropologists are also involved in international human rights investigations (Steadman and Haglund 2005). Finally, some forensic anthropologists holding either masters or doctoral degrees now maintain full-time anthropological positions in medical examiners' offices or crime labs. Clearly, broad-based experiences and education gained in both the natural and social sciences are important as the discipline continues to expand in new directions.

MULTIDISCIPLINARY INTERACTIONS IN FORENSIC SCIENCE

Forensic anthropology forms an integral component of an investigative team in the field, laboratory, and courtroom. For example, during the identification process, forensic anthropologists may work with police investigators, crime scene technicians, forensic pathologists, odontologists (dentists), molecular geneticists, radiologists, and fingerprint experts. New members are added to the team if a case goes to trial, including the attorneys and a variable number of additional forensic specialists, such as ballistics experts, trace evidence examiners, and document examiners, each of whom testifies as to his or her scientific or technical findings. But how does forensic anthropological evidence become integrated with other physical, trace, and circumstantial evidence to make a legally compelling case?

In most criminal cases, the initial responsibility falls upon the lead law enforcement investigator(s) to decide which consultants will have access to certain evidence, how much information to share with each specialist, and when. If a suspect is apprehended and charged, the attorneys join the investigation to weave all available evidence and expert opinions into a complex web of facts that may ultimately be presented in court. Thus, each forensic discipline represents but one thread in the web, and each thread must function together or the entire superstructure will fail. The bones are the hard evidence with which a forensic anthropologist works, but not the only evidence. Communication between experts, strict adherence to the scientific method, and high ethical standards are at the forefront of forensic science, and forensic anthropologists are partners in this process.

SOME ETHICAL ISSUES IN FORENSIC ANTHROPOLOGY

Forensic anthropologists must remember that their reports, testimony, and conduct can have immediate and long-term ramifications for defendants, families, and the judicial process as a whole. Thus, in addition to strict adherence to scientific principles and professional protocols, it is imperative that forensic anthropologists also demonstrate a strong ethical commitment to their work.

Ethical issues underlie all professional actions, many of which go well beyond normal scientific issues. For instance, forensic anthropologists are obligated to report all of their findings, even if they seem contradictory to other lines of evidence or muddy a good timeline or investigative theory (though see Gill-King's poignant story in Chapter 4). Forensic anthropologists are required to keep their cases confidential and not present cases in public or even private settings until they have been legally resolved. They also have a responsibility to protect the identity of the victims and their families when their cases are presented for educational purposes. That said, it should be stated that all of the cases presented in this book have been legally resolved. Further, most authors in this volume have changed or omitted the names of the victims. However, real names are used in a few chapters because the cases have been presented elsewhere, including nationally televised programs, or permission has been granted by appropriate parties.

It may be useful here to distinguish between *evidence* and the *individual*, as these terms are used throughout the text of this book. Evidence can be defined as any object or statement by a witness that has bearing in a court of law. According to Fisher (2000), evidence can take two forms: testimonial and physical (real) evidence. "Testimonial evidence is evidence given in the form of statements made under oath, usually in response to questioning. Physical evidence is any type of evidence having an objective existence, that is, anything with size, shape, and dimension" (Fisher 2000:1). Further, physical evidence is used to "reconstruct the crime, identify participants, or confirm or discredit an alibi" (Geberth 1996:169). Thus, just like blood spatter or a discarded weapon at a crime scene, a lesion on a humerus that was used to determine the identity of an individual or a cut mark on a rib suggestive of the circumstances of death constitute "evidence." However, forensic anthropologists never lose sight of the fact that an individual skeleton with which they work is just that, an individual. The evidence gleaned from the bones of an individual can be presented as such in court, but this application does not detract from the fact that the person was once a living human being who had a history, family, and unique identity. The very fact that forensic anthropologists interpret the life history of a person from their bones argues that they are extraordinarily cognizant of the relationship between "bones" and "individuals."

INTRODUCTION TO THE CASES IN THIS BOOK

This text is divided into six thematic sections representing the most common areas of casework and research in forensic anthropology. Section overviews introduce the chapters and provide contextual information about the applications of forensic anthropology and specific forensic techniques and approaches.

Section I provides a series of cases that exemplify the basic methods of personal identification in forensic anthropology and are discussed below. An essential difference between forensic anthropology and other subdisciplines of biological anthropology is that forensic anthropologists must prepare scientifically valid legal records in the form of case reports, and competently present their results in judicial proceedings. Thus, their methods and reports undergo critical review by their peers as well as non-scientific parties in a court of law.

The chapters in Section II further examine the roles and responsibilities of the forensic anthropologist in the courtroom.

Section III explores the methods utilized to detect and recover human remains. Since humans have devised a number of peculiar methods to dispose of a body, it is difficult to predict just when and where human remains might be found. Forensic anthropologists must have archaeological training to assist law enforcement with the recovery of human remains from a number of different contexts. Basic outdoor search strategies are discussed in the section overview, while the chapters provide specific examples of recovery techniques for a variety of locales. Included in this section are two chapters that cover the efforts of the Joint POW/MIA Accounting Command-Central Identification Laboratory (JPAC-CIL) to recover and identify missing service and civilian men and women in past conflicts around the world.

The chapters in Section IV collectively provide an overview of how forensic anthropologists interpret perimortem trauma and major taphonomic processes from skeletal remains. Two chapters provide an excellent overview of the three types of trauma forensic anthropologists most often encounter—gunshot wounds, sharp force trauma, and blunt trauma. These chapters also illustrate how anthropologists and pathologists work together to interpret trauma in both soft tissue and bone when human remains are decomposed. Blunt trauma is also discussed in a heart-wrenching case of child abuse. One hallmark of child abuse is the presence of multiple trauma of differing ages so the authors incorporate histological techniques to establish the timing of particular injuries. Other cases illustrate how taphonomic principles can be utilized to estimate the postmortem interval (PMI) and establish the context of human bones found in unusual locations.

Section V on analytical methods demonstrates how forensic anthropologists use sophisticated equipment and techniques to address special problems. For instance, when only small fragments of bone are available, certain parameters of the biological profile can be determined from the microstructure of bone (histomorphology), or identity may be established through genetic and anthropological analysis. Experiments can be conducted to replicate tool mark characteristics in bone in order to reconstruct prior postmortem trauma or answer questions about the antiquity of an individual. Techniques presented in these case studies include histomorphology, various facial reproduction procedures, mitochondrial DNA analysis, cut mark analysis, and mass spectrometry.

Finally, Section VI provides some insight into the broad applications and current directions of forensic anthropology. Two applications are presented—mass fatality events and international human rights investigations. The Disaster and Mortuary Operational Response Team (DMORT) is under the Department of Health and Human Services and serves to activate forensic anthropologists in mass casualty situations, such as transportation disasters, bombings, and floods. Finally, two chapters from the Equipo Argentino de Antropología Forense (EAAF), or Argentine Forensic Anthropology Team, demonstrate the ongoing work to identify the disappeared in Argentina, as well as their global efforts to investigate human rights atrocities.

SECTION I CHAPTERS

The cases presented by the multidisciplinary authors in this section demonstrate a variety of difficult challenges, particularly related to the identification process. In Chapter 1, Steadman joins New York State Police Investigator Steve Andersen to present an overview of the basic principles of forensic anthropology and the methods employed in developing a biological profile within the context of a real forensic case.

In Chapter 2, Douglas Ubelaker and colleagues present a case concerning the identification of the dismembered remains of a young woman that were found in several different locations. Scientific investigators were confronted with the task of constructing an accurate biological profile and determining how she died when only incomplete and fragmentary remains were available. The case also demonstrates the importance of multidisciplinary cooperation. The authors, including a forensic anthropologist, a pathologist, a radiologist, and a molecular geneticist, each report on the important contributions they made to the identification process. If any of these specialists had not been involved in the investigation, the case might not have been resolved in such a timely manner.

Karen Burns presents a case in Chapter 3 in which communication among forensic experts broke down, turning a relatively straightforward identification into a lengthy and nearly disastrous predicament. The process of identification is also detailed in this chapter, including the description of antemortem pathologies and anomalies within the skeleton that rendered an accurate description of a biological profile nearly impossible. Burns provides some perspectives as to why interdisciplinary cooperation in this case failed and some suggestions for how to avoid such situations in the future.

This section also examines the impact of missing loved ones on surviving family members. In Chapter 4, Gill-King discusses the evolving technique of computer superimposition in a heartbreaking case from Texas. While he deftly demonstrates the comparative points useful for identification, the impact of the story lies in the ethical dilemma presented by the “incidental” information the anthropologist can garner from skeletal remains. Sometimes the bones tell secrets that are not meant to be shared. Gill-King takes a poignant look at biological paternity and ethical issues concerning if, when, and how potentially harmful incidental information should be released to family members. Finally, the daughter of an Air Force captain who was classified as Missing in Action in Vietnam joins forensic anthropologist Ann Bunch in Chapter 5 to portray the oscillation between heartache, when a loved one is missing, and hope during the identification process.

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The Marty Miller Case: Introducing Forensic Anthropology

Dawnie Wolfe Steadman and Steven A. Andersen

In early April, 1997 shots rang out from a quiet rural area of upstate New York. A man attacked his daughter in their house and shot at her with a shotgun. The woman was able to get to her car and attempted to drive away but the man caught up to her and shot her once through the car door, fatally wounding her. In the mean time, the woman's brother ran to a neighbor's house and called police. The man ran into the woods behind his house and, despite a massive manhunt, was not seen again.

This case became something of a legend in the region given the notoriety of the missing suspect, Marty Miller (not his real name). A tall man known for his quick temper and flair for bar fights, the community was also aware of his family situation. Marty's daughter was also his common-law wife and Marty had three more children with her. The death of his daughter was mourned in the community but there was also a feeling of apprehension. Marty was an avid outdoorsman and knew how to survive in the forest. As a fugitive, Marty could be quite dangerous and people feared where and when he might reappear. As time went on, Marty even became a bit of a boogeyman since parents told their children not to go too deep into the forest because "Marty will get you!"

Four years passed without any word or sign from Marty and the case had gone cold. This changed on

December 8, 2001, when a hunter phoned the local sheriff and stated he had found a human skeleton. Hunters often find missing people given that they visit remote areas that are relatively untouched much of the year, except for hunters and people who wish to hide human remains. The New York State Police were called to investigate the scene and they asked Steadman to help with the recovery and identification of the skeleton.

The remains were on the ground under a great deal of leaf litter. Once the leaves had been cleared, the remains and associated evidence could be seen (Figure 1.1). The skeleton was fully clothed in a black jacket, jeans, leather belt, and boots. A shotgun laid along the left side of the body and shotgun shells were between the legs. Personal effects located around the body included eye glasses with broken lenses, a wrist watch, a partial pack of cigarettes, and a wooden pipe. The skeleton was lying supine next to a tree, though the upper half of the body was twisted to the left such that both arms were on the left side of the body. The hands were disarticulated and the lower arm bones were bleached white by the sun where they extended from the coat sleeves. The skull was highly fragmented and small pieces were found all around the body (Figure 1.2). Some of the bones were transported away from the body by animals. The sacrum was found approximately 50 feet



FIGURE 1.1 SCENE PHOTO OF THE SKELETON FOLLOWING REMOVAL OF LEAF LITTER

Note the shotgun beside the left leg (arrow) and red cartridges between the legs.

away while the right os coxa was recovered approximately 42 feet from the skeleton in the opposite direction. The left os coxa and right femur were not recovered.



FIGURE 1.2 FRAGMENTS OF MANDIBLE AND SKULL (ARROWS) NEAR THE RIGHT HAND

Although a wallet was found in the pants pocket and contained multiple forms of identification with the same name, Martin Miller, wallets are transferrable and thus not an adequate means of positive identification. Instead, a biological identification of the skeletal remains was necessary. The remains were transported to the Forensic Anthropology Laboratory at Binghamton University that night and the analysis began the following morning. The methods utilized in a forensic anthropological analysis require an understanding of the basic principles of skeletal biology that are at the very foundation of the discipline.

A Foundation in Skeletal Biology

Despite the far-reaching applications of modern forensic anthropology, all of the underlying methods and theories in the field are well-grounded in the principles of skeletal biology—the study of the development, anatomy, physiology, histology, and biomechanics of bone tissue. The human skeleton is typically divided into the axial skeleton, comprising the head, thorax, and pelvis; and the appendicular skeleton, which includes the limb bones. Joints articulate (connect) two or more bones. Forensic anthropologists study the anatomy of the 200-plus bones of the adult and subadult skeletons in order to glean as much information as possible from extremely small fragments. In addition, they must be familiar with the morphological variation of the skeleton among individuals and populations. Figure 1.3 is a labeled diagram of the bones of a normal adult skeleton.

Bone is a viscoelastic material, meaning it has both rigid and flexible properties. Approximately 75 percent of bone is inorganic, consisting primarily of minerals, such as calcium and phosphorous, that give bone its rigid strength. However, bone cannot be too rigid or it will become brittle and break upon impact, much like glass. Thus, nearly 90 percent of the organic component of bone is composed of collagen, which provides some flexibility. Further, bone consists of two structural components, compact bone and spongy bone. Compact bone is very hard, dense bone that withstands stress and provides strength, resistance, and protection. The outer cortex of a bone is composed of compact bone. Spongy bone is porous and consists of bony spicules, or trabeculae, that form a latticework to absorb and distribute stress and is found in the interior of the bone.

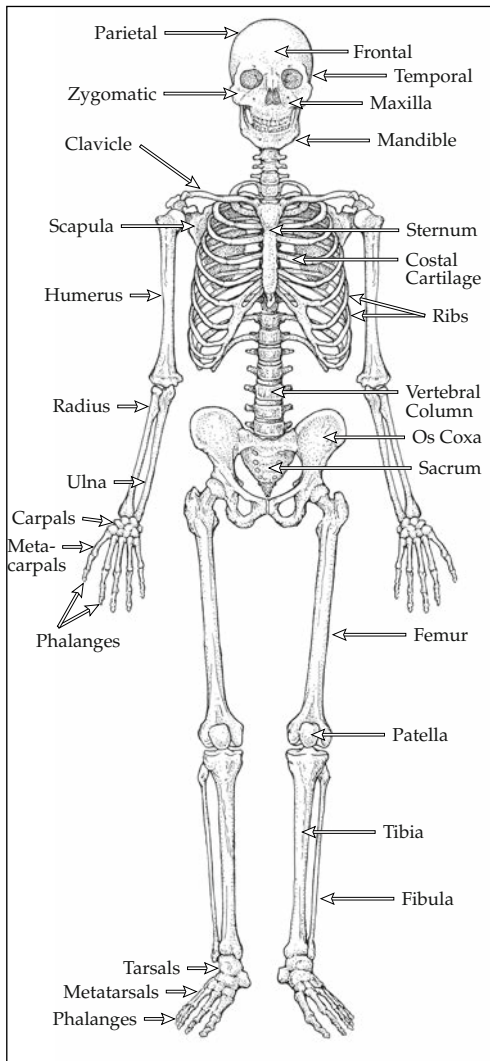


FIGURE 1.3 SOME BONES OF THE ADULT SKELETON

A basic rule of anatomy is that form follows function. Indeed, the structure and morphology of bones are well-adapted for their functions, including support and movement of the body, protection of vital organs, hemopoiesis (blood cell production), and mineral storage. A closer examination of bone architecture will help demonstrate the relationship between the form and function of cortical and spongy bone (Figure 1.4). A long bone is divided into three sections—the diaphysis, or shaft, two or more epiphyses located at the ends of the long bone, and the metaphysis, a section of bone between the epiphysis and diaphysis. A layer of tough connective tissue, known as the periosteum, envelops the outer

cortex of the diaphysis, while the medullary cavity is lined by the endosteum. Long bones function to produce blood cells inside the medullary cavity, provide structure to the body, and act as levers for movement. Accordingly, the outer cortex of the long bone consists of very thick cortical bone to protect the medullary cavity and support the body, while spongy bone is concentrated in the metaphyses and epiphyses, as most stress occurs at the joints. In contrast, short bones, such as those of the wrist (carpals) and ankle (tarsals), function to distribute stress and hence have a relatively thin cortex and a considerable amount of spongy bone. The flat bones of the skull consist of outer and inner tables of compact bone (consider the protective function this provides for the brain), and a layer of spongy bone in between, called diploe.

By applying the principles of skeletal biology, forensic anthropologists have the skills to interpret the story bones tell for the purposes of identification.

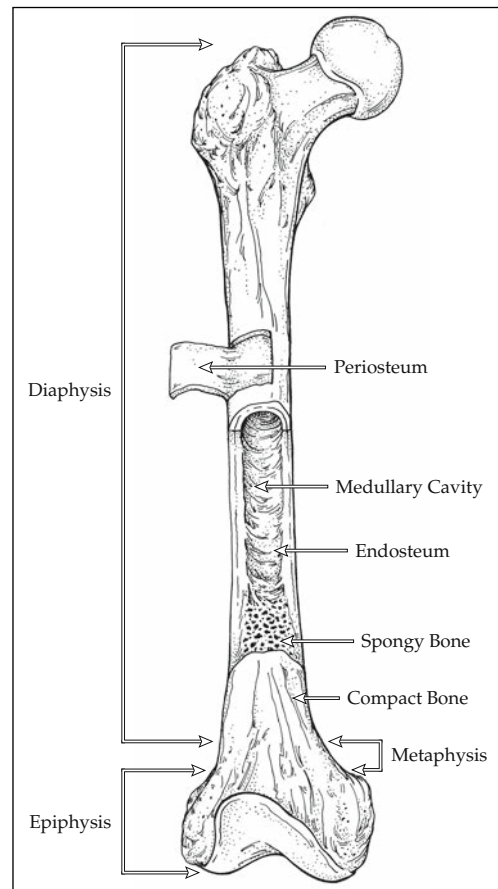


FIGURE 1.4 ANATOMY OF A LONG BONE

The identification process begins with an inventory of the available skeletal elements and other evidence present. The next step is to construct a biological profile of the individual that can be compared to that of missing persons. Finally, a description of any perimortem and postmortem traumatic injuries is required.

Forensic Anthropological Procedures

Inventory

The forensic anthropologist must know how to properly process and sort bones and bone fragments received in a forensic context. The first phase in an osteological analysis is to determine if the bones are human. Typically, the forensic analysis will be terminated if the bones are those of animals. Next, individual bones are identified. If a bone or bone fragment cannot be readily identified, one can attempt to specify the part of the skeleton to which it belongs by assessing the bone type—a long bone (e.g., femur or humerus), flat bone (e.g., bones of the vault), short bone (e.g., bones of the wrist or ankle), or irregular bone (e.g., the vertebrae). Once the bone is identified, the forensic anthropologist determines whether it is from the left or right side of the body in the case of bilateral bones. This procedure is known as “siding.”

When all of the available bones or bone fragments are sorted and sided properly, they should be laid out on a table in anatomical position (Figure 1.5). Standardized forms are used to record the number and identity of the bones present, document their condition, and describe the presence of soft tissue and any associated evidence (Moore-Jansen et al. 1994).

Skeletal Biology and the Biological Profile

The underlying principle of skeletal biology is that certain aspects of an individual’s life history are recorded in his or her skeleton. Bone is a dynamic tissue that adapts to changes in height, weight, age, and activity levels, as well as to certain diseases and traumatic events. Further, aspects of an individual’s population history, or ancestry, are also recorded in the skeleton, as is his or her sex. What story might your skeleton tell about your life history? What is your current height? Are you fairly muscular? Are you right-handed or a southpaw? Are you male or

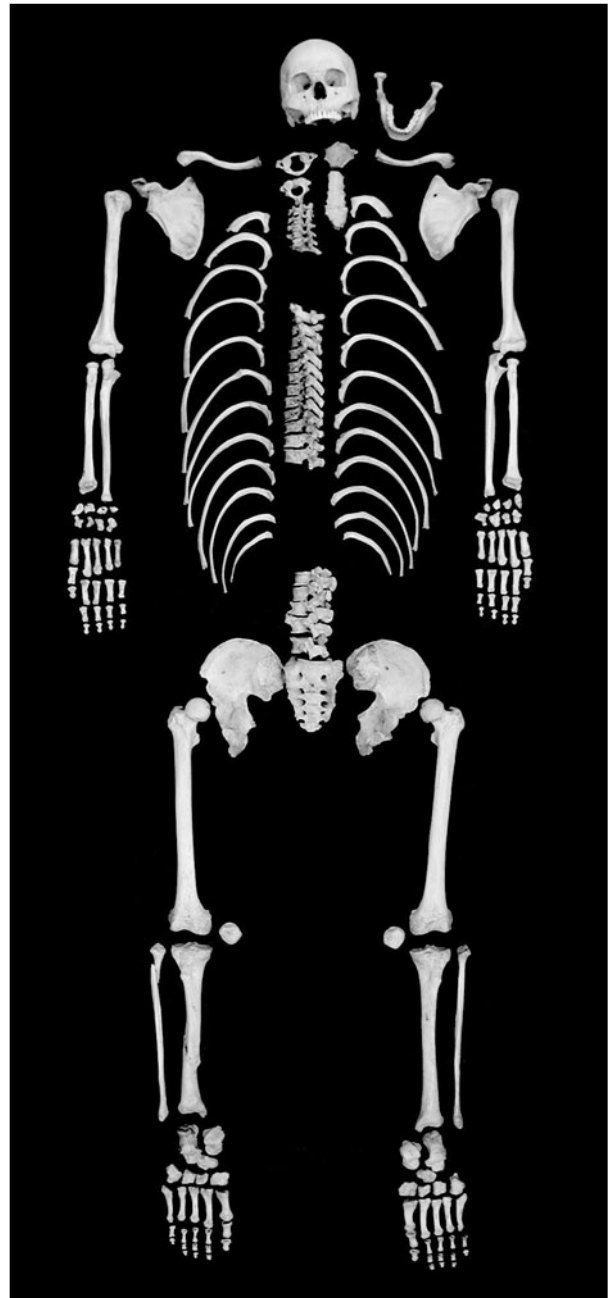


FIGURE 1.5 ANATOMICAL DISPLAY OF A SKELETON FOR INVENTORY AND ANALYSIS

female? Have you ever broken a bone? What other characteristics might make your skeleton unique? How might your skeleton change over the next twenty, thirty, or fifty years? When a person’s death is set within a forensic context, it is the forensic anthropologist’s responsibility to interpret the

CASE STUDY:

Inventory

In the case from New York, several bones were missing due to animal activity. The recovered elements were laid out in anatomical position (Figure 1.6) after cleaning with a toothbrush and water. No soft tissue was present. Note that the sacrum and os coxa, which were exposed to the sun, are whiter in color than the bones that were largely covered by leaf litter where the skeleton was found. The highly fragmented and

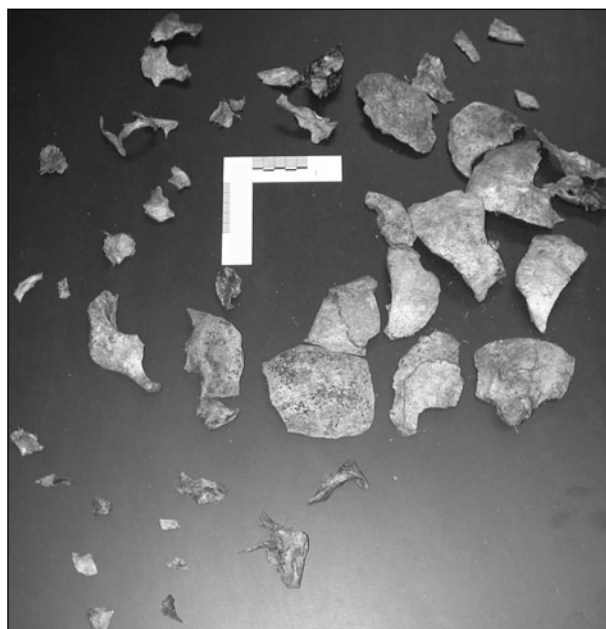
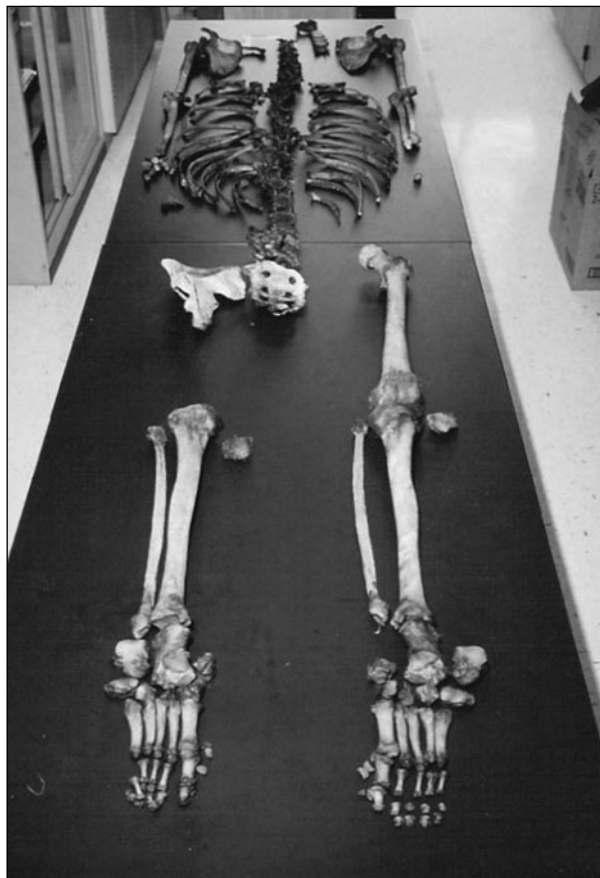


FIGURE 1.6 CASE SKELETON LAID OUT IN ANATOMICAL POSITION (RECOVERED SKULL FRAGMENTS IN INSET)

incomplete elements of the skull and mandible are shown in the inset. None of the skeletal elements were redundant and the remains are consistent with a single individual. Following a complete inventory, a biological profile of the individual can be constructed.

“evidence” recorded in the bones to determine identity and the circumstances of his or her demise. To accomplish this, forensic anthropologists begin by establishing a biological profile of the skeleton—the sex, age, ancestry, and stature, as well as any skeletal anomalies or pathologies that make an individual unique.

Sex The pelvis is considered the most sexually dimorphic skeletal element in humans because the female pelvis must accommodate the relatively large head of an infant during childbirth—a function obviously not shared by males. Thus, the female pelvis is typically wider in every dimension than the male pelvis (Figures 1.7 and 1.8).