Forensic Anthropology
Published and forthcoming titles in the Forensic Science in Focus series

Published

The Global Practice of Forensic Science
Douglas H. Ubelaker (Editor)

Forensic Chemistry: Fundamentals and Applications
Jay A. Siegel

Forensic Microbiology
David O. Carter, Jeffrey K. Tomberlin, M. Eric Benbow and Jessica L. Metcalf

Forensic Anthropology: Theoretical Framework and Scientific Basis
C. Clifford Boyd Jr and Donna C. Boyd

Forthcoming

The Future of Forensic Science
Daniel A. Martell

Humanitarian Forensics and Human Identification
Paul Emanovsky and Shuala M. Drawdy
Forensic Anthropology
Theoretical Framework and Scientific Basis

EDITED BY

C. Clifford Boyd Jr
Department of Anthropological Sciences, Radford University Forensic Science Institute
Radford University, USA

Donna C. Boyd
Department of Anthropological Sciences, Radford University Forensic Science Institute, Radford University, USA
Department of Biomedical Science, Virginia Tech Carilion School of Medicine, Roanoke, USA

WILEY
We dedicate this book to our children, Merritt, Emily, and Forrest, because butterflies taste with their feet.
## Contents

About the Editors, xv  
Notes on contributors, xvii  
Foreword, xxiii  
Series preface, xxv  
Acknowledgments, xxvii  

1 The theoretical and scientific foundations of forensic anthropology, 1  
*C. Clifford Boyd Jr and Donna C. Boyd*  
1.1 Introduction, 1  
1.2 A selective history of theory in forensic anthropology, 2  
1.3 A modern perspective on forensic anthropology theory, 5  
  1.3.1 Three forms of logical reasoning, 8  
  1.3.2 Theory building in forensic anthropology: Linking logic and theory, 10  
1.4 Forensic anthropology theory and modern practice, 12  
1.5 Final comments, 15  
References, 15  

### Part 1 Bias and objectivity in forensic anthropology theory and practice, 19  

2 Subjective with a capital S? Issues of objectivity in forensic anthropology, 21  
*Allysha Powanda Winburn*  
2.1 Introduction, 21  
2.2 Objectivity, subjectivity, and forensic anthropological theory, 22  
2.3 Subjectivity in science, 24  
  2.3.1 Subjectivity in forensic anthropology, 24  
  2.3.2 Effects of bias on forensic anthropology, 25  
  2.3.3 Subjective science is not bad science, 26  
2.4 Mitigated objectivity: A path forward…, 27  
  2.4.1 Constraining subjectivity and bias, 28  
  2.4.2 The continuing process of constraint, 33  
2.5 Conclusion, 34  
References, 34  

3 Navigating cognitive bias in forensic anthropology, 39  
*Michael W. Warren, Amanda N. Friend and Michala K. Stock*  
3.1 Introduction, 39  
3.2 Types of cognitive bias, 40
3.3 Research versus applied science, 41
3.4 Recommended solutions to mitigate confirmation bias, 43
3.5 Challenges unique to forensic anthropology, 44
  3.5.1 Anthropologists work in a variety of professional contexts, 44
  3.5.2 The uniqueness of the forensic anthropology testing sample, 45
  3.5.3 Multiple tests to reach a single conclusion, 45
3.6 An example of how bias affects procedures, 46
3.7 Workable solutions, 49
3.8 Summary, 49
  References, 50

4 Theoretically interesting: Different perspectives of the application of theory to forensic anthropology practice and research, 53
  Soren Blau
  4.1 Introduction, 53
  4.2 Practising in context, 56
  4.3 Ethical considerations for the development of theory, 58
  4.4 Can theories be applied universally?, 59
  4.5 Conclusion, 59
    Acknowledgements, 61
    References, 61

Part 2 The theory and science behind biological profile and personal identification, 65

5 From Blumenbach to Howells: The slow, painful emergence of theory through forensic race estimation, 67
  Stephen Ousley, Richard L. Jantz and Joseph T. Hefner
  5.1 Introduction, 67
  5.2 Race as a concept and theory, 68
    5.2.1 Evolution, rather than race, explains human biological variation, 70
    5.2.2 Human variation is continuous, 72
    5.2.3 Human biological variation involves many traits that typically vary independently, 73
    5.2.4 Genetic variation within so-called races is much greater than the variation among them, 74
    5.2.5 There is no way to consistently classify human beings by race, 75
  5.3 Anthropology and race, 79
  5.4 Forensic anthropology and race, 85
  5.5 Race and the future, 90
    Acknowledgments, 92
    References, 92
The application of theory in skeletal age estimation, 99
Natalie R. Langley and Beatrix Dudzik
6.1 Introduction, 99
6.2 Skeletal age, 101
6.3 Historical context, 101
6.4 Forensic anthropology and evolutionary biology, 102
6.5 Potential solutions to the problem of age estimation, 105
6.6 Final comments, 107
References, 109

Theory and histological methods, 113
Christian M. Crowder, Deborrah C. Pinto, Janna M. Andronowski and Victoria M. Dominguez
7.1 Introduction, 113
7.2 Foundational theory in bone biology, 114
7.3 Interpretive theory in bone biology, 115
7.3.1 Form and function, 115
7.3.2 The mechanostat and Utah paradigm, 116
7.3.3 Exploring the effectors of the mechanostat, 117
7.4 Methodological theory in bone biology, 119
7.4.1 Histological age estimation, 120
7.4.2 Determining human versus nonhuman bone, 121
7.5 Conclusions, 122
References, 123

Forensic applications of isotope landscapes (“isoscapes”):
A tool for predicting region-of-origin in forensic anthropology cases, 127
Lesley A. Chesson, Brett J. Tipple, James R. Ehleringer, Todd Park and Eric J. Bartelink
8.1 Introduction, 127
8.2 What are isotopes?, 128
8.3 Why do isotope compositions of human tissues differ?, 129
8.3.1 Hydrogen and oxygen isotopes, 130
8.3.2 Strontium isotopes, 130
8.3.3 Carbon, nitrogen, and sulfur isotopes, 132
8.4 How do we interpret isotope data collected for forensic human identification?, 133
8.4.1 Oxygen isotopes in drinking water and hair keratin, 134
8.4.2 Oxygen isotopes in drinking water and skeletal bioapatite, 137
8.4.3 Strontium isotopes of local bedrock and skeletal remains, 138
8.5 Examples of the application of isotope analysis to unidentified remains, 139
8.5.1 Jane Doe from Salt Lake County, 139
8.5.2 Mandible from Siskiyou County, 141
Part 3 Scientific foundation for interpretations of antemortem, perimortem, and postmortem processes, 149

9 The anatomical basis for fracture repair: Recognition of the healing continuum and its forensic applications to investigations of pediatric and elderly abuse, 151
Donna C. Boyd

9.1 Introduction: Diagnosing pediatric and elderly non-accidental injury, 151
9.2 Theoretical basis for fracture healing and TSI estimation, 153
9.3 Anatomical basis for fracture healing, 154
9.3.1 Bone growth and development, 155
9.3.2 Fracture healing, 157
9.4 Factors affecting the rate of bone healing, 162
9.4.1 The biological profile (age, sex, ancestry), 162
9.4.2 Type, location, cause, severity, and number of injuries, 163
9.4.3 Injury treatment and local biomechanical factors, 164
9.4.4 Systemic and other factors, 165
9.5 Fracture healing stages and dating systems, 166
9.6 A new model for fracture repair, 174
9.7 Expanding and refining TSI estimation through the Antemortem Fracture Archive, 181
9.8 Theory and the future of TSI estimation, 184
References, 184
Appendix A, 195

10 Theoretical foundation of child abuse, 201
Jennifer C. Love and Miriam E. Soto Martinez

10.1 Introduction, 201
10.2 Case study, 201
10.3 Anthropologists and child abuse, 202
10.4 Foundational theory, 203
10.5 Interpretive theory, 204
10.5.1 Bone biomechanics, 205
10.5.2 Motor skill development, 207
10.6 Methodological theory, 207
10.7 Conclusion, 209
References, 209
11 Bone trauma analysis in a forensic setting: Theoretical basis and a practical approach for evaluation, 213
*Hugh E. Berryman, John F. Berryman and Tiffany B. Saul*
11.1 Introduction, 213
11.2 Theory, 214
   11.2.1 Foundational theory, 215
   11.2.2 Interpretive theory, 216
   11.2.3 Methodological theory, 217
11.3 Fundamental principles in bone fracture interpretation, 218
11.4 A practical approach to bone trauma evaluation and hypothesis building, 226
11.5 Conclusion, 232
References, 232

12 Thinking outside the box: Theory and innovation in sharp trauma analysis, 235
*John A. Williams and Ronald W. Davis*
12.1 Introduction, 235
12.2 Transfer of evidence, 235
12.3 Theory connections, 236
12.4 The human skeleton as transfer evidence, 237
12.5 A primer on saws and dismemberment, 238
12.6 Geographic information system, 240
12.7 Applications of GIS in forensic anthropology and human osteology, 241
12.8 GIS: innovation in cut mark striation interpretation, 242
12.9 Locard and the twenty-first century: It’s all a matter of scale, 247
References, 248

13 The forensic anthropologist as broker for cross-disciplinary taphonomic research related to estimating the postmortem interval in medicolegal death investigations, 251
*Daniel J. Wescott*
13.1 Introduction, 251
13.2 Taphonomy and taphonomic theory, 252
13.3 Forensic taphonomy, 254
13.4 Taphonomy and the estimation of time since death, 255
13.5 The necrobiome, 256
13.6 Cross-disciplinary research, 257
   13.6.1 Need for cross-disciplinary research in PMI estimation, 257
   13.6.2 Cross-disciplinary approaches, 258
13.7 Overcoming barriers to cross-disciplinary research, 262
13.8 Forensic anthropologists as brokers for unified theories in forensic taphonomy, 264
   13.8.1 Forensic anthropologists are already major players, 264
   13.8.2 Anthropologists have a long history of conducting taphonomic research, 264
13.8.3 Anthropology is traditionally a holistic field, 265
13.8.4 Forensic anthropology has its roots in academic research, 265
13.9 Conclusions, 265
Acknowledgments, 266
References, 266

Part 4 Interdisciplinary influences, legal ramifications, and future directions, 271

14 Archaeological inference and its application to forensic anthropology, 273
   C. Clifford Boyd Jr and William W. Baden
   14.1 Introduction, 273
   14.2 Agency and nonlinear systems theories, 274
   14.3 Nonlinear modeling of the decomposition process, 277
   14.4 Discussion, 284
   References, 292

15 Arrows of influence: The give and take of theory between forensic anthropology, archaeology, and geophysics, 297
   John F. Schweikart and Cheryl A. Johnston
   15.1 Introduction, 297
   15.2 Influences of archaeology on forensic anthropology, 299
   15.3 Influences of geophysics on forensic anthropology, 301
   15.4 “Backflow” to other disciplines: Site formation processes in archaeology, 302
   15.5 Backflow: Interpretation/understanding of geophysical signatures, 303
   15.6 Conclusion, 305
   References, 305

16 Forensic anthropology, scientific evidence, and the law:
   Why theory matters, 307
   Donna C. Boyd and C. Clifford Boyd Jr
   16.1 Introduction: Theory in practice, 307
      16.1.1 Commonwealth of Virginia v Lockett:
            Why theory matters, 307
   16.2 Science and the law: The disconnect, 309
   16.3 Science and the law: Commonalities, 310
      16.3.1 Legal and scientific dialogue, 310
      16.3.2 Abductive reasoning, 311
      16.3.3 Probabilistic evaluation of the strength of evidence, 312
   16.4 Forensic anthropologists as expert witnesses, 315
   16.5 Admissibility of forensic anthropology evidence in the post-Daubert world, 316
16.6 The legal application of forensic anthropology: Why theory matters, 318
16.7 Final comments, 319
    Acknowledgments, 320
    References, 320

17 Epilogue: Theory and science in forensic anthropology: Avenues for further research and development, 325
    C. Clifford Boyd Jr and Donna C. Boyd
17.1 The science of forensic anthropology, 325
17.2 Looking forward, 327
    References, 328

Index, 329
About the Editors

C. Clifford Boyd Jr, PhD, RPA, received his PhD in Anthropology from the University of Tennessee–Knoxville in 1986, with a specialty in archaeology. Since 1986, he has taught at Radford University, Virginia, and is currently professor of anthropological sciences, codirector of the RU Forensic Science Institute, and consultant for the Virginia Office of the Chief Medical Examiner. He has conducted archaeological and skeletal analyses of remains from prehistoric, historic, and forensic sites in Tennessee and Virginia for 38 years. In 1998, he was named Professional Archeologist of the Year by the Archeological Society of Virginia. In 2008, he received an Outstanding Faculty Award from the State Council of Higher Education in Virginia. In 2016, he was awarded the Ellis R. Kerley Foundation Research Award for excellence in forensic anthropology research. His research interests include prehistoric and historic archaeology of the southeastern United States, human osteology, forensic archaeology, and anthropological theory.

Donna C. Boyd, PhD, D-ABFA, is eminent professor of anthropological sciences at Radford University, codirector of the Radford University Forensic Science Institute, professor of biomedical science at Virginia Tech Carilion School of Medicine, and consultant for the Virginia Office of the Chief Medical Examiner (VOCME). Dr. Boyd received her PhD in Anthropology in 1988 from the University of Tennessee–Knoxville and has taught at Radford University since 1989. She is the recipient of numerous awards honoring her teaching and research, including the Donald N. Dedmon Professorial Excellence Award for outstanding teaching at Radford University (1998), the Outstanding Faculty Award from the State Council of Higher Education in Virginia (2006), and the United States CASE/Carnegie Outstanding Professor of the Year Award (2006). She is a fellow of the American Academy of Forensic Sciences (AAFS), secretary for the AAFS Standards Board (Anthropology Consensus Group), and secretary and public information officer for the American Board of Forensic Anthropology Board of Directors. She is also a member of the US Department of Health and Human Service’s National Disaster Medical System’s Disaster Mortuary Operational Response Team (DMORT), through which she was deployed to Haiti in February 2010, to recover, analyze, and identify American and Haitian–American earthquake victims. Her current research is on the macroscopic and microscopic skeletal signatures of antemortem and perimortem pediatric and elderly trauma, the estimation of time since injury in pediatric death investigations, and microevolutionary change in the human mandible.
Notes on contributors

Janna M. Andronowski, PhD, is an assistant professor in the Department of Biology, University of Akron, Akron, Ohio. She was formerly a research intern with the Forensic Anthropology Unit at the Office of Chief Medical Examiner in New York City, a research assistant at Simon Fraser University’s Center for Forensic Research, and a postdoctoral fellow in the Department of Anatomy and Cell Biology at the University of Saskatchewan.

William W. Baden, PhD (retired), worked in the Information Technology and Institutional Research Units of Indiana University–Purdue University Fort Wayne. His research focuses on the application of quantitative approaches to anthropological questions, specifically developing nonlinear models of cultural phenomena and, in particular, prehistoric maize agriculture in the Southeastern United States and Mexico.

Eric J. Bartelink, PhD, D-ABFA, has taught for 11 years at California State University, Chico, where he is currently a full professor and director of the Human Identification Laboratory. His research interests focus on the bioarchaeology of Native California, dietary reconstruction using stable isotope analysis, and applications within forensic anthropology. He is a coauthor of Essentials of Physical Anthropology and Forensic Anthropology: Current Methods and Practice and has authored and coauthored numerous articles in scientific journals.

Hugh E. Berryman, PhD, D-ABFA, is a research professor with the Department of Sociology and Anthropology and director of the Forensic Institute for Research and Education at Middle Tennessee State University. Since 1997, Dr. Berryman has provided forensic anthropology consultation to the Defense POW/MIA Accounting Agency-Central Identification Laboratory in Hawaii and the Office of the Metropolitan and Davidson County Medical Examiner. He serves on the Crime Scene Subcommittee of the Organization of Scientific Area Committees (OSAC). His research interests include bone trauma, bone fracture interpretation, and skeletal crime scene processing. In 2012, he received the T. Dale Stewart Award for lifetime achievement.

John F. Berryman, MS, holds a BS degree in mechanical engineering from the University of Tennessee, Martin, and an MS in aerospace engineering from Virginia Tech, Blacksburg. His research interests have varied from the use of finite element analysis to examining bone fracture propagation to software development including coauthoring a book entitled Relevant Search: With Applications for Solr and Elasticsearch.
Soren Blau, PhD, is the senior forensic anthropologist at the Victorian Institute of Forensic Medicine (VIFM) where she has been employed since 2005. She is an adjunct associate professor in the Department of Forensic Medicine at Monash University, a founding fellow of the Faculty of Science of the Royal College of Pathologists of Australasia, and a recipient of a Churchill Fellowship (2013). She has undertaken consultancies for the International Criminal Court (ICC) and the International Committee of the Red Cross (ICRC) and participated in the recovery and analysis of human remains from archaeological and forensic contexts in numerous countries. She is the coeditor of the *Handbook of Forensic Anthropology and Archaeology* (2009, 2016).

Lesley A. Chesson, MS, is the president of IsoForensics, Inc., a private analytical services and research firm located in Salt Lake City, UT, that focuses on forensic applications of stable isotope techniques. She was approved as a forensic practitioner by the Forensic Isotope Ratio Mass Spectrometry Network (FIRMS) in 2013 and is a member of the FIRMS Steering Group. She has applied stable isotope analysis for more than 14 years to examine drugs, explosives, foods, and beverages. One of her current areas of focus is assisting law enforcement in investigations via the stable isotope analysis of unidentified human remains.

Christian M. Crowder, PhD, D-ABFA, is director of the Forensic Anthropology Division for the Harris County Institute of Forensic Sciences in Houston, Texas. Previously, he was the chief anthropologist for the Office of the Armed Forces Medical Examiner and deputy director of Forensic Anthropology Unit for the Office of Chief Medical Examiner in New York City. He has also worked as an anthropologist for the Defense POW/MIA Accounting Agency in Hawaii and the International Criminal Tribunal for the former Yugoslavia. In addition to his practitioner duties, he is adjunct faculty at Pace University in New York City and at the University of Toronto, Ontario.

Ronald W. Davis, PhD, is a former assistant professor of Geosciences and Natural Resources and National Resource Conservation and Management at Western Carolina University. His research interests include wildlife ecology and management, GIS, and remote sensing.

Victoria M. Dominguez, MA, spent 4 years with the Forensic Anthropology Unit of the Office of Chief Medical Examiner in New York City. Currently, she is a PhD candidate in the Division of Anatomy at the Ohio State University (OSU). She is also the laboratory manager for the Skeletal Biology Research Laboratory, a part of the Injury Biomechanics Research Center at OSU. Her principal research interest is in bone histology, particularly the use of histology for human versus nonhuman differentiation, age-at-death estimation, and the influence of microarchitecture on bone mechanics.
**Beatrix Dudzik, PhD**, is an assistant professor of anatomy at the DeBusk College of Osteopathic Medicine of Lincoln Memorial University. She received her PhD in biological anthropology at the University of Tennessee. Her research interests and publications focus on morphological variation of the skull in Asian populations, forensic age estimation methods, and forensic taphonomy.

**James R. Ehleringer, PhD**, is a distinguished professor at the University of Utah, where his research focuses on ecological, environmental, and forensic applications of naturally occurring stable isotopes (nature’s natural recorders) in water, atmospheric gases, and biological materials. He is a member of the US National Academy of Sciences and a recipient of the Rosenblatt Prize for Excellence. He is also senior scientist at IsoForensics, Inc.

**Amanda N. Friend, MA**, is a PhD student in the Department of Anthropology at the University of Florida and is a forensic anthropology assistant in the C.A. Pound Human Identification Laboratory (CAPHIL) where she also currently serves as the senior analyst. Her research interests include undocumented border crosser deaths in Florida, ancestry assessment, and isotopic variation.

**Joseph T. Hefner, PhD, RPA, D-ABFA**, is currently an assistant professor of anthropology at Michigan State University. His research interests focus on morphological variation in cranial form within and between modern human populations. In particular, he works with morphoscopic traits, parametric and nonparametric classification statistics, and machine learning methods useful for the assessment of ancestry in forensic anthropology.

**Richard L. Jantz, PhD** (emeritus professor), has taught at the University of Tennessee since 1971, serving as director of the UT Forensic Anthropology Center from 2000 to 2011. His research interests mainly include quantitative human variation with an emphasis on American populations, both early and recent. In the mid-1980s, he established the forensic anthropology data bank and, along with Steve Ousley, developed ForDisc software that automates estimation of sex, ancestry, and height from skeletal measurements. His primary research in forensic anthropology deals with improving estimates of sex, ancestry, and height and documenting the changes occurring in the American population during the twentieth century. He is now an emeritus professor and is enjoying working on research that has been put off for decades.

**Cheryl A. Johnston, PhD, D-ABFA**, is a Lecturer at the Center for Life Sciences Education at the Ohio State University. She has worked as a consultant in forensic anthropology since 1991 for numerous agencies in North Carolina and Ohio, including the Ohio Attorney General’s Office Consumer Protection Division, the Ohio Bureau of Criminal Identification and Investigation, and the US Fish and
Wildlife Service. Her interests in forensic anthropology include cultural modification of human bone, decomposition, and thermally altered bone.

**Natalie R. Langley, PhD, D-ABFA**, is a senior associate consultant in the Department of Anatomy at the Mayo Clinic School of Medicine in Scottsdale, AZ, and an adjunct faculty member in the University of Tennessee Anthropology Department and the DeBusk College of Osteopathic Medicine Anatomy Department. Her research interests include skeletal maturation in modern populations, age and sex estimation from the human skeleton, secular changes in skeletal biology, currency of forensic standards, skeletal trauma, and anatomy education. In 2007, the AAFS Forensic Sciences Foundation awarded her the Emerging Forensic Scientist Award for her research in skeletal maturation.

**Jennifer C. Love, PhD, D-ABFA**, is currently the forensic anthropologist and identification unit supervisor for the Office of Chief Medical Examiner (OCME) in Washington, DC. Prior to joining the OCME, she served as the forensic anthropology director at the Harris County Institute of Forensic Sciences in Houston, TX. She is a member of the Anthropology Subcommittee of the Organization for Scientific Area Committees (OSAC). Her research interests are bone trauma, bone pathology, and decedent identification. In 2011, she coauthored the textbook *Skeletal Atlas of Child Abuse*.

**Miriam E. Soto Martinez, PhD**, received her PhD in biological anthropology from the University of Tennessee in 2015. She has been working at the Harris County Institute of Forensic Sciences since 2013. Her research interests include child abuse, growth and development, and sexual dimorphism in subadults.

**Stephen Ousley, PhD**, has been a professor at Mercyhurst University in Erie, Pennsylvania, since 2007. From 1998 to 2007, he was the director of the Repatriation Osteology Laboratory in the Repatriation Office of the National Museum of Natural History at the Smithsonian Institution, where he developed multivariate statistical methods to estimate ancestry of human remains in the Smithsonian’s collections. Most of his professional activities involve anthropological databases, computer programming, and statistical approaches to biological anthropology. His research interests include forensic anthropology, human growth and development, and human variation. With Richard Jantz, he coauthored ForDisc, discriminant function software for sex, ancestry, and height estimation.

**Todd Park** is a cold-case investigator for the Unified Police Department of Greater Salt Lake, Utah.

**Deborrah C. Pinto, PhD, D-ABFA**, is a forensic anthropologist with the Harris County Institute of Forensic Sciences in Houston, Texas, and has been with the
agency since 2010. Her research and publications focus on adult and pediatric trauma as well as anthropological methods using bone histology.

**Tiffany B. Saul, PhD,** is currently a research assistant professor with the Forensic Institute for Research and Education at Middle Tennessee State University. Her research interests include the use of stable isotopes and trace elements for the identification of human remains, trauma analysis, and the role of anthropologists in humanitarian and human rights responses, including disaster response and human rights investigations.

**John F. Schweikart, MA, RPA,** is an archaeologist with Search Recovery Consultants, LLC, with over 20 years' field and laboratory experience working collaboratively with the Ohio Bureau of Criminal Investigation and Identification (BCII), North Carolina State Bureau of Investigation (SBI), the Franklin County (Ohio) Coroner, and various county law enforcement agencies in Ohio, North Carolina, and West Virginia. He has served as guest instructor for forensic anthropology training courses for the York Regional Police, Ontario, Canada.

**Michala K. Stock, MA,** is a PhD candidate in the Department of Anthropology at the University of Florida and a forensic anthropology analyst in the C.A. Pound Human Identification Laboratory (CAPHIL). Her research focuses on the growth and development of sexual dimorphism in the crania of humans and apes.

**Brett J. Tipple, PhD,** is a senior research scientist at IsoForensics, Inc. in Salt Lake City, Utah, and a research assistant professor within the Department of Biology at the University of Utah. His research interests are in the fields of isotope geochemistry, plant ecology, and social geochemistry. Some of his current areas of research are plant ecophysiology and applications of heavy isotopes from human tissues for provenancing.

**Douglas H. Ubelaker, PhD, D-ABFA,** is a curator and senior scientist at the Smithsonian Institution’s National Museum of Natural History in Washington, DC, where he has been employed for nearly four decades. He is also a professorial lecturer with the Departments of Anatomy and Anthropology at the George Washington University, Washington, DC, and is an adjunct professor with the Department of Anthropology, Michigan State University. He has published extensively in the general field of human skeletal biology with an emphasis on forensic applications. He served as the 2011–2012 president of the AAFS and was named Distinguished Fellow in 2016. He has received numerous honors, including the Memorial Medal of Dr. Aleš Hrdlička, Humpolec, Czech Republic; the Anthropology Award of the Washington Academy of Sciences; the T. Dale Stewart Award of the Physical Anthropology Section of AAFS; the FBI Director’s Award for Exceptional Public Service; and a special recognition award from the FBI.
Michael W. Warren, PhD, D-ABFA (retired), was director of the C.A. Pound Human Identification Laboratory at the University of Florida. His research areas of interest include forensic identification and trauma analysis, human variation, and forensic examination of cremated human remains. He is coeditor of The Forensic Anthropology Laboratory.

Daniel J. Wescott, PhD, is associate professor in the Department of Anthropology and the director of the Forensic Anthropology Center at Texas State University. His forensic anthropological research focuses on developing and testing methods for defining biological profiles, interpreting the postmortem interval, and reconstructing trauma from human skeletal remains. He is a recipient of the Ellis Kerley Award for excellence in forensic anthropology research.

John A. Williams, PhD, D-ABFA, is a professor of anthropology at Western Carolina University. His primary interests are in the interpretation of bone trauma, especially dismemberment. He has consulted with medical examiners, various law enforcement agencies, and the FBI.

Allysha Powanda Winburn, PhD, is an assistant professor of anthropology at the University of West Florida. She has worked previously as a forensic anthropologist at the Defense POW/MIA Accounting Agency and as quality assurance coordinator of the University of Florida’s C.A. Pound Human Identification Laboratory. In addition to the study of ethics, error, and objectivity in forensic anthropology, her research interests include pelvic age estimation and medicolegal interpretations of ritual remains used in African diaspora religious practices.
As the field of forensic anthropology has advanced and flourished, critics have emerged. During the formative years of the discipline, some anthropology colleagues, who were not engaged in forensic applications, contrasted forensic casework and research with more traditional endeavors, labeling the former as “police work” largely devoid of a theoretical foundation. Those of us active in forensic anthropology at that time simply shrugged these comments off, viewing them as reflective of ignorance of the reality of the field and also a bit of jealously regarding its visibility. With time, these critiques have waned. Fueled by surging student interest in forensic anthropology and administrative responses, some of these former critics now find themselves involved with teaching courses in forensic applications.

Today, forensic anthropology is recognized as an important subdiscipline of anthropology. Emerging forensic anthropologists can find jobs in university faculties, medical examiners’ offices, human rights organizations, government facilities, and many other sites. Anthropologists are integrated into recovery teams. Anthropological analysis of recovered remains is sought after and highly valued. Data and interpretations offered by forensic anthropologists have contributed in critical ways to the solutions of many medicolegal problems.

In spite of this progress, some concern lingers, especially among the older generation of anthropologists, regarding the robusticity of method and theory within forensic anthropology. Today, much like before, such doubts remain rooted in ignorance of the complexity of the modern practice of forensic anthropology. Some concerns reflect criticism of the overall field of forensic science and its perceived needs of more robust methodology, error analysis, assessment of cognitive bias, and related issues.

This volume addresses such concerns in a comprehensive manner. Forensic anthropology, like other forensic science disciplines, is case-driven but also represents applied science. The quality of these applications reflects advances, as well as knowledge of the underlying science. To address issues presented by a particular case or set of evidence, the forensic anthropologist turns to the relevant science at hand. At the general level, the available science reflects method and theory in the studies of evolution, growth and development, anatomy, physics, engineering, chemistry, archaeology, and of course the broad fields of anthropology and physical anthropology. In addition, certain methods and theories derived from research and casework experience are specific to the unique forensic applications. This book presents detail on the many different levels of method and theory in forensic anthropology.

Nonlinear systems theory is included in this discussion. Throughout its history, progress in the field of forensic anthropology has been distinctly nonlinear.
Promising new methods have emerged from research on specific samples. However, in many cases, enthusiasm for these methods has waned when testing on different samples has revealed reduced accuracy. Although irregular, progress has been sustained by increasingly critical research and the growing availability of new documented collections. Research has become increasingly interdisciplinary and international. Simultaneously, anthropologists have eagerly taken on issues of error analysis, cognitive bias, and many of the concerns that ripple through forensic science today.

In my view, this volume represents a welcomed addition to the scientific literature in forensic anthropology and the more general field of forensic science. The book documents in a comprehensive and exhaustive manner what forensic anthropologists have known all along; method and theory are alive and well in the dynamic and rapidly growing field of forensic anthropology.

Douglas H. Ubelaker
Smithsonian Institution
Washington, DC, USA
The forensic sciences represent diverse, dynamic fields that seek to utilize the very best techniques available to address legal issues. Fueled by advances in technology, research and methodology, as well as new case applications, the forensic sciences continue to evolve. Forensic scientists strive to improve their analyses and interpretations of evidence and to remain cognizant of the latest advancements. This series results from a collaborative effort between the American Academy of Forensic Sciences (AAFS) and Wiley to publish a select number of books that relate closely to the activities and Objectives of the AAFS. The book series reflects the goals of the AAFS to encourage quality scholarship and publication in the forensic sciences. Proposals for publication in the series are reviewed by a committee established for that purpose by the AAFS and also reviewed by Wiley.

The AAFS was founded in 1948 and represents a multidisciplinary professional organization that provides leadership to advance science and its application to the legal system. The 11 sections of the AAFS consist of Criminalistics, Digital and Multimedia Sciences, Engineering Sciences, General, Pathology/Biology, Questioned Documents, Jurisprudence, Anthropology, Toxicology, Odontology, and Psychiatry and Behavioral Science. There are over 7000 members of the AAFS, originating from all 50 States of the United States and many countries beyond. This series reflects global AAFS membership interest in new research, scholarship, and publication in the forensic sciences.

Douglas H. Ubelaker
Senior Scientist
Smithsonian Institution
Washington, DC, USA
Series Editor
The editors wish to thank the chapter contributors who accepted the challenge of exploring theoretical applications of their expertise in the discipline of forensic anthropology. They are particularly indebted to Dr. Douglas H. Ubelaker and the American Academy of Forensic Sciences for soliciting and supporting this project. Many thanks also to Jenny Cossham, Elsie Merlin, and P. Sathishwaran at Wiley Blackwell for their many helpful edits and suggestions.