

# Section I

## *Context*

# 1 *Introduction*

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## 1.1 Introduction

Introductory chapters in edited biological anthropology volumes often follow a stock, six-part formula: (1) explain why a component/ability/process of the human/non-human primate body/skeleton is of consequence, and can tell us so much about the origins/adaptation/affinities/health of an individual or population, (2) characterize the sub-field that studies said component/ability/process, (3) sing the myriad praises, and/or mention several shortcomings of that sub-field, (4) present an historical overview, (5) summarize the contributed chapters and relate how they tie in with parts 1–4, and (6) provide a vision of the sub-field's future direction(s). Such predictability may explain why many readers skip the Introduction, and head straight for the “meat” (i.e., the substantive chapters) of such books. For that reason we will leave out much of this standard material, with the exception of the chapter summaries, and primarily recount the genesis of the present volume; summaries are still presented to acknowledge the many talented contributors who made this volume possible, and to highlight and link together their diverse and, in some cases, cutting-edge dental research under a common, unifying theme, i.e., methodology.

In brief, it is unnecessary to expound on the qualities of the body/skeleton component covered in this volume – the dentition, or the sub-field of study used – dental anthropology, and/or, for that matter, the merits of such study (e.g., enamel is hard and preserves well, enamel does not remodel, the interaction between teeth and environment, the high genetic component in expression, teeth evolve slowly, both living and dead subjects can be directly compared, etc.); these issues were all previously detailed in innumerable books, including: Brothwell's (1963) *Dental Anthropology*, Kelley and Larsen's (1991) *Advances in Dental Anthropology*, and many others (e.g., Alt *et al.*, 1998; Dahlberg, 1971; Harris, 1977; Hillson, 1986, 1996; Jordan *et al.*, 1992; Kieser, 1990; Nichol, 1990; Scott, 1973; Scott and Turner, 1997). Indeed, it is precisely because of the

many useful attributes of teeth, and their study, that so many dental publications exist.

With regard to the history of dental anthropology, most of these same publications contain pertinent information (see Dahlberg, 1991), whereas others focus on the subject, especially concerning early accomplishments in the sub-field (e.g., Scott, 1997). Moreover, Richard Scott and Christy Turner contributed an updated history of dental study, concentrating on the twentieth century, to this volume (Chapter 2); thus, again, there is no need to provide such an overview here in the Introduction.

Lastly, as practicing dental anthropologists we, the editors, do have our respective visions regarding where the sub-field stands, and where it is headed. But why take our word for it? A principal goal of this volume is to illustrate the current and future direction(s) of dental anthropology in the subsequent chapters (a.k.a., the “meat”).

## 1.2 Origins of the present volume

The creation of an edited volume was set in motion at the 2004 Dental Anthropology Association (DAA) meeting in Tampa, Florida; a question arose concerning what to do about the DAA’s 20th anniversary meeting that was to be held the following year in Milwaukee, Wisconsin. The DAA is an international organization whose yearly gatherings are held in conjunction with those of the American Association of Physical Anthropologists (AAPA); additional details are provided in Chapter 2. Regarding the question, it was decided that a dental anthropology symposium should be organized. Past DAA president, John Lukacs, suggested that it cover the “state of the science” in the sub-field. That is, what established approaches are being used and what may be on the horizon? We supported the idea and set about organizing a symposium for 2005 that, fittingly, was entitled “Dental Anthropology 20 Years After: The State of the Science.” The abstract in the 2005 AAPA meeting issue describes the symposium’s intent:

Commemorating the 20th anniversary meeting of the Dental Anthropology Association, this symposium highlights recent research in the sub-field that is illuminating issues of fundamental anthropological importance. Using both established and innovative new methodological and technological approaches, scholars with interests ranging from the micro- to macroscopic levels of structure and expression present their latest findings on dental genetics, histology, growth and development, pathology, and morphometrics across a broad range of living and

fossil human and non-human primate taxa. Thus, unlike many symposia that focus on specific topics and/or regions, the unifying theme here is diversity. The intent is to assess the current state of the sub-field, emphasize its insights into diverse anthropological questions, and explore its potential future directions. (Irish and Nelson, 2005, p25)

Thirteen papers by 20 authors and co-authors were presented. A discussion led by John Lukacs and DAA past-president, Edward Harris, followed. At least a dozen or so additional researchers could have easily been added to the program if time allowed. In any event, the symposium succeeded in its stated goals and was well received. As such, it was decided that the next logical step was to publish and disseminate the papers.

### 1.3 Content, links, and objectives

All lead and most co-authors in the symposium, many of whom are renowned researchers in their respective areas of study, contributed to the present volume. Most subjects covered here are either unchanged or represent substantial expansions relative to the original material. To address the obligatory exclusion of some important context and research in the symposium, and based on the advice of the anonymous reviewers of our book proposal, several additional chapters (2, 3, 7, 12, and 17) were solicited.

Although the subsequent 17 chapters do highlight sub-field diversity (i.e., the original stated intent), they are linked together here by an overarching theme that stresses methodology, to warrant use of the phrase “technique and application” in the title. Specifically, they comprise a range of methods – from basic observation and recording, to advanced computer-based imaging and analysis. The result is a cross section of modern dental study. Although many pertinent books have been published since *Advances in Dental Anthropology*, a truly comprehensive survey of methods – many of which can be readily employed by the reader – is not among them; the present volume is intended as a follow-up to that 1991 compendium. It can provide a useful reference for advanced undergraduate students, graduate students, and professionals in the social and life sciences, as well as interested dental clinicians. It should also be useful as a contemporary reader in courses covering human and other primate teeth; as it now stands, many instructors supplement their main text by placing assorted current journal articles and book chapters on library reserve for their students.

To provide a framework for the various topics, this volume is divided into four parts or sections: (1) Context, (2) Applications in Assessing Population Health, (3) Applied Life and Population History, and (4) Forefront of Technique. The

focus and sequence of these sections also serve to take us from where we are at present, to where we are headed as a sub-field of biological anthropology.

The first section includes this Introduction, the aforementioned history by Scott and Turner, and a review of statistical applications in dental anthropology by Edward Harris (Chapter 3). As Harris relates in his introduction, “[i]t may seem odd to have a chapter on statistics in a book discussing advances in dental anthropology.” However, a thorough understanding of how to apply and interpret the results of statistical methods is, today, a necessity in almost all areas of dental research. Thus, his chapter provides additional “context” for the remainder of the volume.

The second section contains five chapters that address various aspects of population health at the micro- through macroscopic levels of analysis. First, in Chapter 4, Debbie Guatelli-Steinberg explores the use of perikymata (i.e., enamel growth layers evident on sides of crowns) within hypoplastic defects to estimate duration of growth disruptions in recent and fossil human teeth. Her comparisons indicate that mean stress periods in a sample of Alaskan Inupiaq were greater than in Neandertals; a comparable finding was noted for *Australopithecus* versus *Paranthropus*. Second, using laser ablation inductively coupled plasma mass spectrometry, Louise Humphrey, Teresa Jeffries, and Christopher Dean (Chapter 5) evaluate lead and zinc distributions in human deciduous tooth enamel. Their findings, that both elements vary in concentration throughout the crown (e.g. high at the enamel surface), have implications for reconstructing early life history from elemental studies of teeth. Third, in Chapter 6, Simon Hillson covers the most important and pervasive of all dental diseases: caries. He discusses the etiology and diachronic variation of caries, from prehistoric through recent times and, in the process, provides background for the two subsequent section chapters. Fourth, John Lukacs and Linda Thompson (Chapter 7) conduct a global survey of published caries data, and conclude that there is a difference in prevalence by sex throughout much of human prehistory. In contrast to standard anthropological explanations of sex differences that focus on culture and behavior, they propose that differences in caries susceptibility by sex are due to differing life history events, particularly those surrounding women’s reproductive biology. Lastly, Brian Hemphill (Chapter 8) closes out this section by introducing a new quantitative approach that links the examinations of dental pathology prevalence with dental pathology pervasiveness. An analysis of individuals at the site of Tepe Hissar, Iran revealed that, depending upon individual gender and status, an increase in wealth did not necessarily lead to a corresponding improvement in dental health.

The volume’s third section is comprised of six contributions relating to life and population histories. Gary Schwartz and Christopher Dean (Chapter 9) start things off by focusing on dental growth and development in non-human

primates. Using examples from a sub-fossil lemur (*Megaladapis edwardsi*) and living great ape (*Gorilla gorilla*), they show how construction of a bar chart illustrating dental chronology (initiation, duration, and completion of the dentition) can complement and clarify life history inferences derived from other means. This growth and development theme is carried over into the study of humans by Helen Liversidge in Chapter 10. She describes ways to measure dental growth and maturation, presents various methods to estimate age from these references, compares the methods, and finally provides some useful insight and recommendations. Peter Ungar and Jonathan Bunn (Chapter 11) next demonstrate the use of a computer-based approach, i.e., dental topographic analysis, to interpret primate dental functional morphology. Beyond summarizing this novel approach, they present findings on diet in two Old World monkey species through a comparative study of variation in occlusal slope and relief at given attrition stages.

Like the three preceding chapters, Christopher Schmidt's contribution (Chapter 12) addresses dental development, age, and idiosyncratic features. In this case, however, these and other dental indicators (along with additional evidence) are discussed in the context of helping forensic dental anthropologists, together with forensic dentists, to identify accident and crime scene victims. Moving from identifying individuals to estimating relatedness among populations, Shara Bailey (Chapter 13) compares the teeth of Neandertals and modern humans to determine if observed morphological differences are typical of sub-specific or closely related specific taxa. To help gauge the level of these differences, comparisons are made with *Pan* – a sister taxon of *Homo*. Lastly, Chapter 14, by Oliver Rizk, Sarah Amugongo, Michael Mahaney, and Leslea Hlusko, provides something of a bridge to the rest of the volume. Beginning with an overview of prior dental heritability research, it relates how dental variation (a major component of the preceding chapters) is influenced by genetic factors, and how future quantitative genetics research will help us to better understand the evolution of our primate relatives and ancestors.

The fourth and final section, as its title indicates, highlights the forefront of dental technique. This is not to say that the preceding chapters do not; as noted, they entail such topics as high-tech recording and computer-based applications, a new quantitative approach, and future directions in genetics, among others. And, of course, “cutting-edge” techniques do not necessarily have to be “high-tech” (e.g., see FitzGerald and Hillson (below)). However, Chapter 15 certainly is. In their exploration of incision, Kalpana Agrawal, KaiYang Ang, Zhongquan Sui, Hugh Tan, and Peter Lucas go beyond traditional bite mechanics to explore how the fracture mechanics of food may affect tooth shape. Noting that spatulate-shaped incisors of primates are rare in other mammals, they report that such teeth are well adapted for two things: peeling

fruit and stripping leaves – both of which involve more than simple biting. On the other hand, Charles Fitzgerald and Simon Hillson (Chapter 16) simply, but inventively, update an old low-tech method, i.e., dental measurements, while reviewing their analysis of human dental reduction since the Pleistocene. Rather than mesiodistal and buccolingual crown diameters, that are susceptible to even slight attrition, they record less vulnerable cervical diameters using specially designed calipers.

Still, what good is a section on cutting-edge dental research without the inclusion of at least some truly ground-breaking methodology? In Chapter 17, Peter Ungar, Robert Scott, Jessica Scott, and Mark Teaford describe dental microwear texture analysis, and use it in the study of eight anthropoid taxa. This new imaging technique provides a fast, objective alternative to standard SEM microwear analyses, and provides much more information on diet and tooth use. The final contribution (Chapter 18) by Roberto Macchiarelli, Luca Bondioli, and Arnaud Mazurier involves actual “space-age” technology. Using monochromatic high photon flux-based  $\mu$ CT analyses on a variety of extinct hominoids and hominids, they were able to obtain high-resolution images of internal dental structures; this new approach, though currently beyond the reach of many dental researchers, provides a potential glimpse of the future, in that it yields useful data without resorting to traditional, destructive thin-sectioning of teeth.

## 1.4 Conclusion

This introduction has, we hope, whetted your appetite for what follows. The 17 chapters comprising the “meat” of *Technique and Application in Dental Anthropology* provide an excellent snapshot of “the state of the science” as the first decade of the twenty-first century winds down. In putting this volume together, we strived to include both established and up-and-coming researchers to present as broad a representation of sub-field methodology as space allowed. Therefore, it should contain at least a few valuable nuggets for every reader, whether student, professional, or clinician. After all, because of the many aforementioned attributes of teeth, along with their ubiquity in the fossil record, most individuals with an interest in human/non-human primate origins/adaptation/affinities/health are *de facto* dental anthropologists. Since, as we all know and are forever repeating, “teeth are the hardest substance in the body,” they are terrific little time capsules that retain numerous, pertinent data. As we continue to refine, develop, and apply dental anthropology techniques, our ability to retrieve these data will only increase – so that the next 20 years will, undoubtedly, be even more productive than the last 20.

## References

- Alt, K. W., Rösing, F. W., and Teschler-Nicola, M., eds. (1998). *Dental Anthropology: Fundamentals, Limits, and Prospects*. New York: Springer.
- Brothwell, D., ed. (1963). *Dental Anthropology*. New York: Pergamon Press.
- Dahlberg, A. A., ed. (1971). *Dental Morphology and Evolution*. Chicago: The University of Chicago Press.
- Dahlberg, A. A. (1991). Historical perspective of dental anthropology. In *Advances in Dental Anthropology*, ed. M. A. Kelley and C. S. Larsen. New York: Wiley-Liss, pp. 7–11.
- Harris, E. F. (1977). Anthropologic and genetic aspects of the dentition of Solomon Islanders, Melanesia. Ph.D. Dissertation, Arizona State University.
- Hillson, S. (1986). *Teeth*. Cambridge: Cambridge University Press.
- Hillson, S. (1996). *Dental Anthropology*. Cambridge: Cambridge University Press.
- Irish, J. D. and Nelson, G. C. (2005). Session 9. Dental anthropology 20 years after: the state of the science. *American Journal of Physical Anthropology*, **Supplement 40**, 25–6.
- Jordan, R. E., Abrams, L., and Kraus, B. S. (1992). *Kraus' Dental Anatomy and Occlusion*. St. Louis: Mosby Year Book.
- Kelley, M. A. and Larsen, C. S. eds. (1991). *Advances in Dental Anthropology*. New York: Wiley-Liss.
- Kieser, J. A. (1990). *Human Adult Odontometrics*. Cambridge: Cambridge University Press.
- Nichol, C. R. (1990). Dental genetics and biological relationships of the Pima Indians of Arizona. Ph.D. Dissertation, Arizona State University.
- Scott, G. R. (1973). Dental morphology: a genetic study of American white families and variation in living southwest Indians. Ph.D. Dissertation, Arizona State University.
- Scott, G. R. (1997). Dental anthropology. In *History of Physical Anthropology. Volume I, A-L*, ed. F. Spencer. New York: Garland Publishing, pp. 334–340.
- Scott, G. R. and Turner, C. G. II. (1997). *The Anthropology of Modern Human Teeth: Dental Morphology and its Variation in Recent Human Populations*. Cambridge: Cambridge University Press.

## 2 *History of dental anthropology*

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### 2.1 Introduction

In 1991, Albert A. Dahlberg wrote “Historical perspective of dental anthropology” for the volume *Advances in Dental Anthropology* (Kelley and Larsen, 1991). A few years later, the senior author (Scott, 1997) wrote an historical paper on “Dental anthropology” for Frank Spencer’s 1997 edited volume on the *History of Physical Anthropology*. Dahlberg was both a dentist and a pioneer in the field of dental anthropology. Because of those two abiding interests, his historical treatment focused as much on developments in oral biology as on the history of dental anthropology per se. Scott, a physical anthropologist, dealt with the early history of dental research, but the overall focus of his article revolved around the manner in which teeth have been used in anthropological research. Given the recency of these two articles, we do not want to simply reiterate points already made. Moreover, in no way is this general contribution comparable to articles on the history of dental anthropology in circumscribed geographic areas, such as those written for Australia (Brown, 1992, 1998) and Hungary (Kósa, 1993). We applaud these efforts and encourage other workers to document the history of the field in their country or region.

Our goal is to focus broadly on the growth of dental anthropology during the twentieth century and comment on potential directions in the twenty-first century. Specifically, this chapter addresses: (1) how scholars have used teeth to address and resolve anthropological problems, (2) recent developments in the field, including the founding of the Dental Anthropology Association, the growth of dental anthropology in Russia and China, and the spate of new dental books published during the past 15 years, (3) the development and significance of standardization in the field, (4) a survey showing how physical anthropologists teach dental anthropology directly, or incorporate its methods and principles into closely allied courses in osteology, bioarchaeology, human biology, primate anatomy, and paleoanthropology, and (5) recent and projected trends in dental anthropology.

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## **2.2 How teeth have been used to further the aims of anthropological inquiry**

The role of the physical anthropologist is to describe biological variation and explain it in terms of adaptation, evolution, and history. As teeth are under strong genetic control and are also the only hard part of the skeleton directly exposed to the environment, this variation takes different forms (Scott and Turner, 1988). Genetic information is sought in the size, shape, and morphology of teeth, along with numerical deviations away from a species' dental formula. Some variation is environmental in origin, such as the crown wear produced by normal food mastication; wear may also be of cultural origin, in that it is not induced by chewing, but is a byproduct of intentional and unintentional cultural practices that leave an imprint on the teeth (Milner and Larsen, 1991). Because teeth develop along a strongly programmed developmental path, environmental stressors are inferred by micro- and macrostructural defects in the enamel and dentine.

If dental anthropologists are concerned with genetic and environmental variation provided by teeth, who are the objects of study? *Homo sapiens*, or recent and modern humans, are the primary focus of dental anthropologists. However, dental anthropologists also study fossil ancestors back to the point of hominid origins and beyond – to fossil and living primates. Species studied outside this order, while interesting as animal models for stress, asymmetry, development, inheritance, and the like, are not considered part of dental anthropology per se, as the problems addressed are biological rather than anthropological in nature. Perhaps this is an artificial distinction, but boundaries have to be drawn somewhere or the entire field of oral biology would have to be reviewed – a daunting task. In discussing historical foundations for research on recent humans, fossil hominids, and non-human primates, each section is divided roughly by research before and after 1950, about the time physical anthropologists started thinking in terms of the modern evolutionary synthesis.

### **2.2.1 Research on recent humans (living, skeletal)**

In pre-Darwinian times, the nascent field of physical anthropology focused on human racial variation and classification. Teeth played almost no role in these early discussions, as workers focused on externally visible characteristics like skin, hair, and eye color, hair and nose form, stature, etc. By the end of the nineteenth century, with but few exceptions (e.g., P. Broca and crown wear, W. H. Flower and tooth crown size, L. H. Mummery and oral pathology), teeth had yet to enter anthropological consciousness in any significant way (Scott, 1997).