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Introduction to dental anthropology

'Show me your teeth and I will tell you who you are', Baron Georges Cuvier, the great eighteenth–nineteenth century zoologist and anatomist, is supposed to have said. This comment was really in the context of comparative anatomy, and refers to Cuvier's delight in reconstructing whole extinct animals from fossil fragments of their dentitions, but it will do just as well for human teeth. For anthropologists studying archaeological, fossil and forensic remains, the teeth are possibly the most valuable source of evidence in understanding the biology of ancient communities, following the course of evolution and identifying an individual from their fragmentary remains. Dental anthropology might therefore be defined as a study of people (and their close relatives) from the evidence provided by teeth. Teeth have a distinct anatomy and physiology, all their own and wholly different to the biology of the skeleton, and teeth are also unique amongst the resistant parts of archaeological and fossil remains in having been exposed on the surface of the body throughout life. Dental anthropology can therefore be studied in the mouths of living people, using much the same techniques as are employed for ancient remains. It is thus not surprising that practising dentists have always been prominent amongst dental anthropologists, with anatomists and other oral biologists from schools of dentistry, in addition to researchers whose training lies more in biological anthropology. The exposure of teeth in the living mouth is also very useful when training anthropologists, as everyone carries their own reference material with them – students can just open their mouths and look in a mirror.

One of the main themes of dental anthropology has been a study of variation in size and shape of the teeth, as recorded in casts of living mouths or seen in the skulls of archaeological and fossil collections. This work is founded on a series of classic 'odontographies' – dental studies of particular ethnic groups or fossil collections such as those of Robinson (1956) on the australopithecines

from South Africa, Weidenreich (1937) on the Chinese *Homo erectus*, Campbell (1925) on Aboriginal Australians, Moorrees (1957b) on the Aleuts and Pedersen (1949) on the Inuit. It was particularly brought to prominence during the second half of the twentieth century by the late Al Dahlberg, who amassed a large collection of casts from his work as a dentist with living Native Americans, and acted as a focus for the development of dental anthropology through his graduate training programme at the University of Chicago and his role in the establishment of a series of Dental Morphology Symposia (page 68). The widespread use of the phrase 'dental anthropology' probably dates to the forerunner of these symposia, a meeting held in London during 1958 (Brothwell, 1963a), which was celebrated 30 years later by a symposium of the American Association of Physical Anthropologists in Kansas City (Kelley & Larsen, 1991). In 1986, a Dental Anthropology Association was formed during a meeting of the AAPA at Albuquerque, New Mexico, and now numbers amongst its membership most of the active researchers in the field.

Dental anthropology is, however, a much wider subject than just morphology. It includes a study of the development of teeth in relation to age, their appearance in the mouth, and the processes of wear and other changes that occur once they are in place. It also includes the microscopic traces, preserved inside the tissues of the teeth, of the growth and ageing processes. Yet another area of interest is the study of dental diseases, in relation to diet and other factors, and the most recent development is a study of the biochemistry of dental tissues. These ideas and techniques have entered anthropology from oral biology, whose roots lie in odontology, a subject that is little mentioned nowadays but which has formed the scientific basis for modern dental surgery. Odontology has its origins in research at many centres during the eighteenth and nineteenth centuries (Hofman-Axthelm, 1981), but one major focus for its early development as a coherent discipline was the Royal College of Surgeons in London, whose museums were founded with the personal collections of the extraordinary surgeon polymath John Hunter (1771; 1778). Successive curators included Sir Richard Owen (1845), Sir John Tomes (1894) and Sir Frank Colyer (1936; Miles & Grigson, 1990) who, between them, published key texts on odontology. Many of their original specimens, illustrated in their great works, can still be seen at the Odontological Museum and Hunterian Museum of the Royal College of Surgeons and continue to act as an important resource.

The present book has been written mainly for biological anthropologists, amongst whom there are several different groups with an interest in teeth. One of the largest of these groups (known as bioarchaeologists in America)

focuses on collections of human remains that have been excavated from archaeological sites, aiming to reconstruct the demography, biological affinities, diet, health and general way of life of past populations from a range of skeletal and dental evidence. The teeth are particularly resistant to the destructive effects of long burial in the ground, and thus occupy an important place in this work. Archaeological collections are often compared with similar studies of living people, and one further advantage of teeth is that direct comparisons can readily be made. Forensic anthropologists make up another group with an interest in teeth. Their aim, in most cases, is to identify very fragmentary remains and the teeth become important when the remains are so damaged as to make identification difficult by any other means. Forensic anthropology is usually considered to be distinct from forensic dentistry (often called forensic odontology), which concentrates particularly on such matters as bite marks, or matching dental records with evidence for dental surgery, so these areas have deliberately not been included here as there are several texts that deal with them in detail (Cottone & Standish, 1981; Whittaker & MacDonald, 1989; Clark, 1992). Anthropological methods come into their own where the remains have no evidence of dental treatment or it is not possible to find dental records for matching purposes – still a common enough occurrence in many parts of the world amongst those unable to afford treatment. Palaeoanthropologists make up another large group, with an interest in the fossil remains of (mostly extinct) primates, and they overlap with primatologists, who are concerned with the biology and behaviour of both living and fossil representatives of the primates. Full consideration of teeth in these fields would have expanded the book out of reasonable bounds, so the focus has been restricted to our own species *Homo sapiens* and our closest relatives. There are enough similarities within this group for descriptions of dental anatomy and physiology to cover them all, but their place within a broader range of primates is dealt with elsewhere (Swindler, 1976; Aiello & Dean, 1990).

We and our closest relatives are usually included in the family Hominidae (hominids), which is combined with the great apes or family Pongidae (pongids), into the super-family Hominoidea. There is a great deal of dispute about the correct way of dividing living and extinct hominids and pongids into families and species, and in any text some decision is needed about which terms and definitions to use (the terms used in this book are given in Table 1.1 and are an attempt to follow the most widespread practice). The australopithecines are a relatively well-defined group of African hominid fossils, and many researchers now separate the less heavily built of these into the genus *Australopithecus*, whilst placing the more robust into a separate genus *Paranthropus* (Grine, 1988). They have since been joined by the fossil remains

Table 1.1. *The family Hominidae*

Species	Sites	Stratigraphic division	Date ranges
Australopithecines			
Ardipithecus ramidus	East Africa	Pliocene	*c.* 4.4 Ma BP
Australopithecus anamensis	East Africa	Pliocene	4.2–3.9 Ma BP
Australopithecus afarensis	East Africa	Pliocene	3.75–2.8 Ma BP
Australopithecus africanus	South Africa	Pliocene	3–2.5 Ma BP
Paranthropus robustus	South Africa	Lower Pleistocene	1.8–1.5 Ma BP
Paranthropus boisei	East Africa	Pliocene, Lower Pleistocene	*c.* 2.6–1.2 Ma BP
Hominines			
Homo habilis	Africa (+ ?)	Pliocene, Lower Pleistocene	2.2–1.6 Ma BP
Homo erectus	Asia (+ Africa for earlier dates)	Middle Pleistocene	700–125 ka BP (1.9 Ma BP, 1.6 Ma BP)
Homo sapiens (archaic)	Africa + Europe	Middle Pleistocene	700–125 ka BP
Homo sapiens (Neanderthal)	Europe + West Asia	Upper Pleistocene	100–35 ka BP
Homo sapiens (anatomically modern)	Worldwide	Upper Pleistocene + Holocene	90 ka BP, 50 ka BP –present

BP, years before present; Ma, millions of years; ka, thousands of years; Holocene, 10 ka BP–present; Pleistocene, 2 Ma–10 ka BP; Pliocene, 5.1 Ma–2 Ma BP.

from Aramis in Ethiopia, which were originally labelled *Australopithecus* (White *et al.*, 1994), but have now been placed in a new genus *Ardipithecus* (White *et al.*, 1995). A further recent addition to the australopithecines is the new species *Australopithecus anamensis* (Leakey *et al.*, 1995), defined on fossil finds from Kenya. The other major genus within the Hominidae is *Homo* itself, and there is considerable argument about which of the earlier African fossils should be included in it. The species *Homo habilis*, as originally defined, includes a rather variable collection of specimens and it is now suggested that these may be better divided into two species (Wood, 1991). Similarly, whilst the core of *Homo erectus* is clearly defined as a group of Middle Pleistocene fossils from China and Java, earlier specimens referred to it are more controversial. The species *Homo sapiens* is frequently divided into three groups, and some researchers actually give these different species names too. Archaic *Homo sapiens* as used in this book includes a heterogeneous collection of Middle Pleistocene specimens from Africa and Europe. Neanderthals are a much more clearly defined group, with a core of specimens from Western Europe and material assigned from Eastern Europe and Western Asia. Anatomically modern *Homo sapiens* includes living people throughout the world and similar fossils from the Upper Pleistocene.

The organization of this book

Basic field and laboratory methods applying to the dental anthropology of archaeological, museum and forensic remains are outlined in Appendix A. Chapters 2, 3 and 4 all deal with morphology. The aim of Chapter 2 is to describe the basic anatomy of teeth and to summarize the criteria for identifying them that are most useful in anthropology, especially with fragmentary material. Chapter 3 is one of the largest sections, because it deals with morphological variation – the core of dental anthropology for many people – whilst Chapter 4 examines dental occlusion, or the way in which teeth fit together. Chapter 5 is concerned with the development of the teeth during childhood, concentrating on the important evidence that this provides for age-at-death in childrens' remains. Chapters 6, 7, 8 and 9 all cover different aspects of the microscopic structure of dental tissues, passing from enamel, to dentine and then cement, and the age estimation methods that are based upon them. Much of the discussion is concerned with images from dental microscopy, for which details are given in Appendix B for those unfamiliar with microscope work. Chapter 10 covers the relatively new field of the biochemistry of dental remains, which is likely to be the focus of much future research. Chapter 11 deals with the wear of teeth and the evidence it yields about age and diet, whilst Chapter 12 explores dental disease and its interpretation particularly in relation to the diet. The conclusion, Chapter 13, attempts to summarize the main achievements of dental anthropology, the problems and possible future directions. This book makes no attempt to quote the whole literature of dental anthropology – no book could – but it does attempt to provide an introduction to the main skills required, the major issues raised, with a pathway to the literature so that readers can follow up these arguments themselves. The bibliography is therefore one of the largest sections.

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Dental anatomy

Terms and definitions

Further details for modern *Homo sapiens* are given in Jordan *et al.* (1992), Carlsen (1987), van Beek (1983) and Woelfl (1990), whereas details for other hominids are available in a variety of sources (Robinson, 1956; White *et al.*, 1981; Wood & Abbott, 1983; Wood *et al.*, 1983; Grine, 1985; Wood & Uytterschaut, 1987; Wood *et al.*, 1988; Wood & Engelman, 1988; Wood, 1991; White *et al.*, 1994), and the patterns of wear described in this chapter are based on the work of Murphy (1959a). Carlsen provided an alternative terminology of 'fundamental macroscopic units' for describing tooth morphology, which is not included here because it has not yet been employed in dental anthropology. For comparisons with non-human mammal teeth see publications by Hillson (1986a; 1992c) – the main potential confusions are with bear and pig molars, with incisors in deer, cattle and their relatives, and the great apes, which are described in detail, along with other primates, by Swindler (1976).

Labels for teeth

Each child has two dentitions. The deciduous (or milk) dentition is about half-formed by birth and erupts into the mouth during the next two years (page 124). It is replaced gradually by the permanent dentition, for which the first tooth starts to form just before birth, and the last tooth is finally completed in the early twenties. Each dentition is divided into four quadrants: upper left, upper right, lower left and lower right. Left and right quadrants are separated by the midline of the skull (the median sagittal plane) – so that the upper left quadrant mirrors the upper right and the lower left mirrors the lower right (Figure 2.1). Within each quadrant there are different classes of teeth – incisors (Latin *dentes incisivi*; cutting teeth), canines (Latin *dentes canini*; dog teeth),

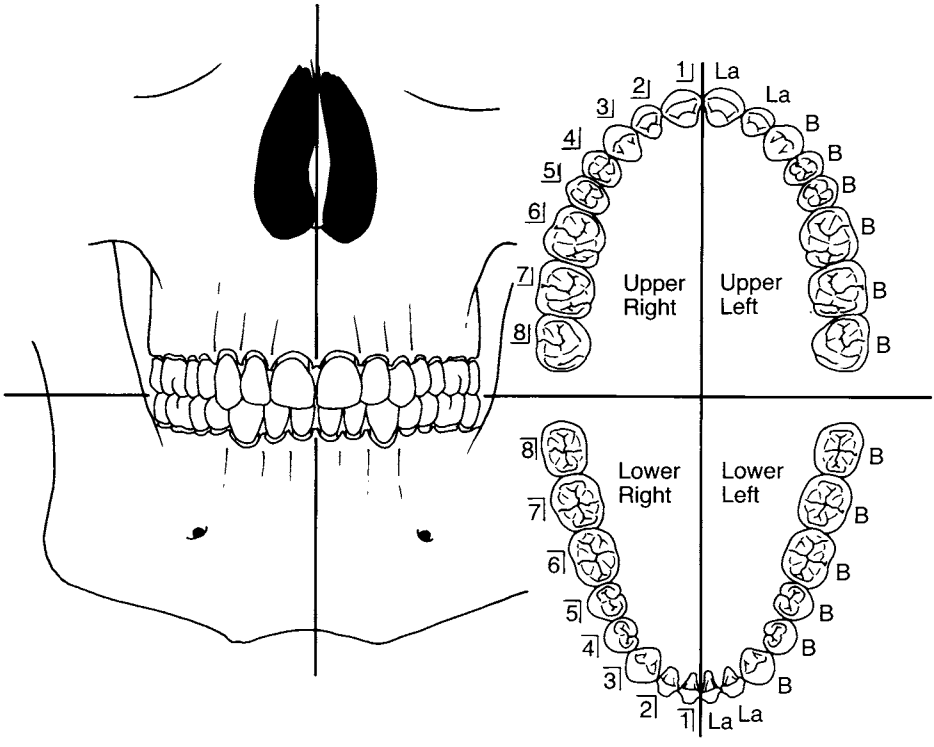


Figure 2.1 Quadrants of the permanent dentition (see Table 2.1). La, labial surfaces; B, buccal surfaces.

premolars and molars (Latin *dentes molares*; grinding teeth) – and incisors and canines are often described together as anterior teeth, whilst premolars and molars are called cheek teeth. In each quadrant of the permanent dentition there are normally two incisors, one canine, two premolars and three molars. Each quadrant of the deciduous dentition similarly comprises two incisors, one canine and two cheek teeth, which are normally called deciduous molars but which are, properly speaking, deciduous premolars. This problem arises because the traditional names in dentistry were adopted without reference to palaeontology. In the mammals as a whole, it is considered that deciduous dentitions consist only of incisors, canines and premolars, and there may be up to four premolars in each quadrant, depending on the species. In the case of human deciduous dentitions, the two 'molars' are equivalent to the third and fourth premolars of other mammals but, in spite of this, they continue to be called the first and second deciduous molars in human dentistry. There is a similar problem with the permanent premolars, which are described in (human) dental texts as the first and second premolars but are really third and fourth

premolars. For consistency, however, the traditional dental terms are used in this book (Table 2.1).

Tooth names are cumbersome and several shorthand notations are used in dentistry (Table 2.1). The Zsigmondy system denotes the deciduous teeth of each quadrant by lower case letters (a – e), the permanent teeth by numbers (1–8), and the quadrants themselves by vertical and horizontal bars. Another common notation is the Fédération Dentaire Internationale (1971) two digit system, where the first digit indicates quadrant and dentition, and the second digit denotes the tooth. The FDI system is designed for rapid entry into computer databases and is ideal for anthropological recording of large collections.

Components and surfaces in tooth crowns and roots

Each tooth is divided into a crown and a root. The crown is the part that projects into the mouth and the root is embedded in the jaws. Dentine is the tissue that forms the core of the whole tooth, and the crown is coated with enamel whilst the root is coated with a thin layer of cement (Figure 2.3). The boundaries between these tissues are termed the enamel–dentine junction (EDJ), cement–dentine junction (CDJ), and cement–enamel junction (CEJ). The meeting point between the crown and the root is the *cervix* (Latin; neck – cervical is used as an adjective for this part of the tooth) and, for some reason, this formal anatomical name is retained today whilst the formal names *corona* (Latin; crown) and *radix* (Latin; root) are rarely used, even though their adjective derivatives coronal and radicular are often employed. The base of the crown is called the cervical margin and, girdling the cervical one-third of the crown, there is often a broad bulge called the *cingulum* (Latin; girdle). Inside the tooth is the pulp chamber, containing the soft tissue of the pulp, with small conical hollows (horns or diverticles) in its roof, and a floor which opens into a root canal, or canals. A tooth may have several roots, each with a root canal, and the point at which roots are divided is known as the root fork, or furcation.

The aspect of the crown (Figure 2.2) that faces teeth in the opposing jaw when the mouth closes is known as the occlusal aspect (Latin *facies occlusalis*; closed up face). In human molars and premolars there are broad crown surfaces that actually meet when the jaws shut, and these can truly be called occlusal surfaces, but incisors and canines are tall and spatulate with high crowns that do not normally meet edge-to-edge, and overlap instead (page 114). In anterior teeth, it is therefore clearer to call the occlusal extremity of the crown the incisal edge (Latin; *margo incisalis*). The complete opposite of occlusal is the aspect which contains the tips of the roots and, as the tip of each root is known as its apex, this is called the apical aspect.

The remaining four aspects of each tooth are labelled in relation to its

Table 2.1. *Tooth labelling systems*

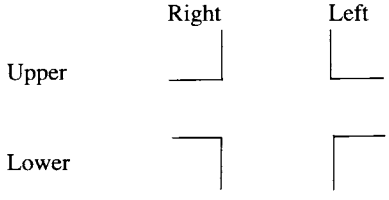
Deciduous dentition

Tooth name	Zsigmondy system	FDI system
First incisor (often called 'central' incisor)	a	1
Second incisor (often called 'lateral' incisor)	b	2
Canine	c	3
First molar (more correctly the third premolar)	d	4
Second molar (more correctly the fourth premolar)	e	5

Permanent dentition

Tooth name	Zsigmondy system	FDI system
First incisor (often called 'central')	1	1
Second incisor (often called 'lateral')	2	2
Canine	3	3
First premolar (more correctly the third premolar)	4	4
Second premolar (more correctly the fourth premolar)	5	5
First molar	6	6
Second molar	7	7
Third molar	8	8

Zsigmondy system lines to denote jaw quadrants



Examples of Zsigmondy system

⌊6 = permanent upper left first molar

c⌉ = deciduous lower right canine

FDI system codes to denote quadrant

Permament dentition

	Right	Left
Upper	1	2
Lower	4	3

Deciduous dentition

	Right	Left
Upper	5	6
Lower	8	7

Examples of FDI system

26 = permanent upper left first molar

83 = deciduous lower right canine

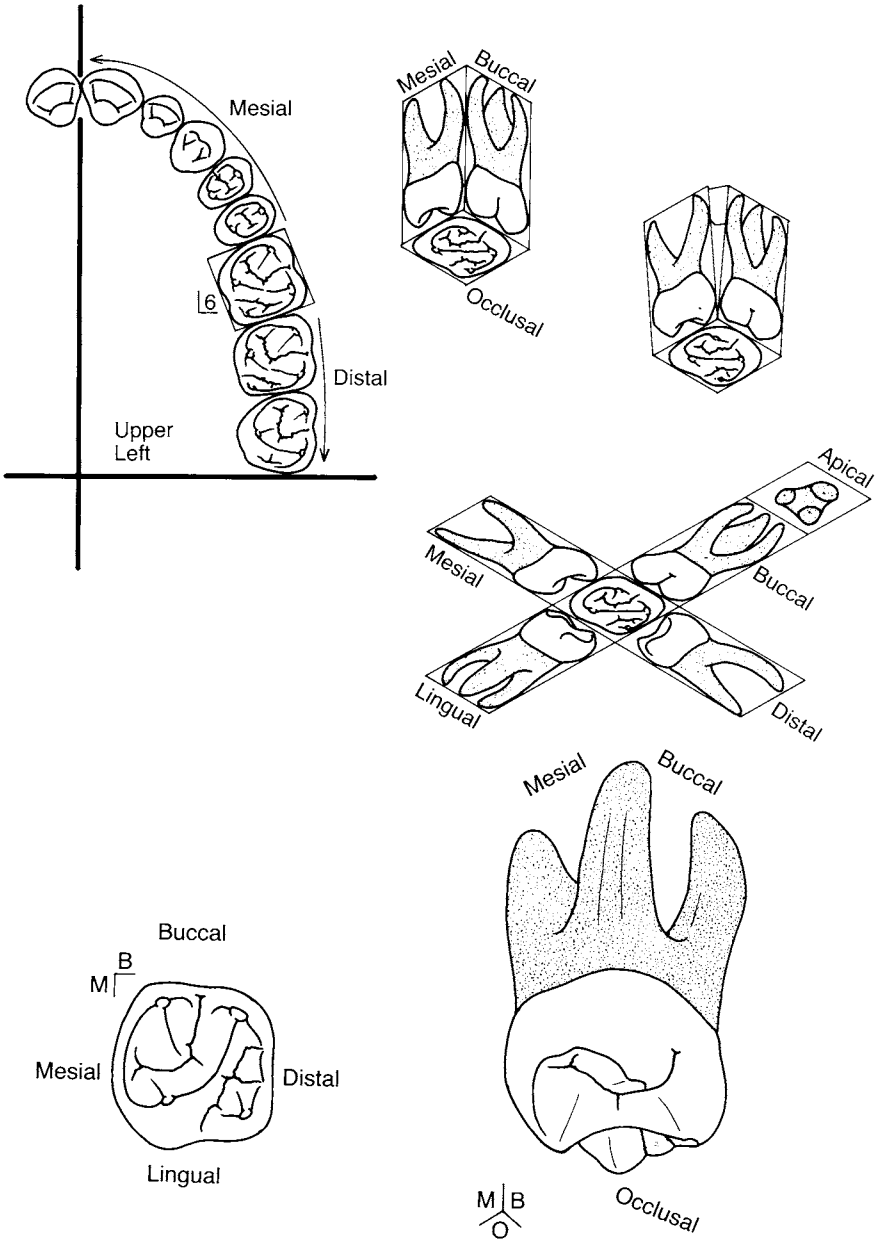


Figure 2.2 Labelling surfaces and orientation of teeth. Permanent upper left first molar. Upper half of figure: the six aspects (See Table 2.2). Lower half of figure: orthogonal projection of occlusal surface and isometric projection of mesial–buccal–occlusal surface, showing the method of labelling orientation in Chapter 2 by marking one corner with abbreviations (M, mesial; D, distal; O, occlusal; B, buccal; La, labial; Li, lingual).