DIET AND DENTAL HEALTH IN PREDYNASTIC EGYPT:
A COMPARISON OF HIERAKONPOLIS AND NAQADA

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By

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By

Tammy R. Greene

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ABSTRACT

Seven dietary indicators on 364 dentitions of working class Predynastic Egyptians from Hierakonpolis and Naqada are examined in this dissertation. The majority of the samples from both sites date to the Naqada II period (3500-3200 BC), during which these were the two main urban centers for Upper Egypt. Both sites are located on the west bank of the Nile approximately 130 km from one-another. The samples consist of adults and juveniles ranging from 6 years to over 50 years of age. The dietary indicators, which include caries, calculus, abscess, periodontal disease, macrowear, microwear, and hypoplastic enamel defects are used to look for statistically significant differences between working class inhabitants of the two sites as well as between the sex and age groups within each site. The analysis is used to address four main research questions. (1) What combination of the above indicators is the best for establishing an overall picture of diet and dental health? Results illustrate the importance of using a wide array of indictors. (2) Which of the available flora and fauna were being eaten? While each specific food could no be identified individually, cultivated items, such as wheat, barley or millet were being eaten in the form of bread, that raw vegetables were consumed by all individuals at Hierakonpolis but mostly women and children at Naqada, and that at least some meat and/or fish was consumed at both sites. (3) Were food types found as burial offerings being eaten? Consumption of at least two burial offerings, bread and yellow nutsedge (Hierakonpolis only), are supported by the data. (4) Were the working class inhabitants of Hierakonpolis and Naqada consuming the same diet? Differences and similarities in the diet and dental health between inhabitants of the two sites are examined. While the major

portions of the diet appear to be similar, this study found both dietary and behavioral differences between the working class members of these sites.

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CHAPTER ONE

INTRODUCTION

This dissertation describes the examination of an array of dietary indicators on the dentition of working class Predynastic Egyptians. The term 'working class', as used here, was established by the excavators to refer to the food producers and is determined by the dimensional size, style and wealth of the burials, as well as the number of burials within the cemeteries (e.g., Friedman, 1999; Jones, 2002; Nardo, 2004; Rose, 2001). Diet and dental health are compared between the working class inhabitants of Hierakonpolis and Naqada in Upper Egypt. Due to the size and wealth of these sites, they are considered prime centers during the time period studied here (Naqada II –Early Naqada III) (Kemp, 1989). Within and between population comparisons are made in diet and/or dental health, and in cultural practices as reflected in diet between sex and age groups and between these two large urban centers.

The reconstruction of diet and dietary habits among individuals of various ages, sexes and population groups can reveal a great deal about lives of ancient peoples (Beckett and Lovell, 1994; Chamberlain and Witkin, 2003; Dahlberg, 1960; Hillson, 1979; Larsen et al., 1991; Leigh, 1925; Puech, 1986; Schmidt, 1998; Smith, 1972; Walker, 1981, and many others), and through archaeology has the potential to yield insights into the living experience and constitution of inequalities based on age, sex, and status (Meskell, 2002). Unfortunately, food remains in the archaeological record are often insufficient to accurately reconstruct diet. Vegetal material, which may compose up to 80% of some prehistoric diets worldwide, do not preserve well (Wahome, 1990). In addition to natural taphonomic factors, food processing and cooking may influence the preservation of plant macro-remains (Fahmy, 1995). In Upper Egypt, annual flooding and thousands of years of subsequent settlement and cultivation have largely destroyed the sites from which food evidence would be most useful (Arkell, 1975; Bard, 1992; Wenke, 1989). However, there are an increasing number of methods available to aid in the reconstruction of diet using the human skeleton, including stable isotope analysis, trace element analysis, examination of metabolic diseases manifest on the skeleton and dental analysis.

The focus of this study is on dietary evidence present on dentition. Teeth are the best indicators of diet for this study because: (1) They are less porous and denser than bone, and thus are more likely to survive in the archaeological record; (2) there is a close association between teeth and behavior - everything that is ingested comes into contact with the teeth, and non-food items may also be placed in direct contact with the teeth when teeth are used as a tools; (3) unlike bone, once teeth are formed they do not remodel - thus, stresses recorded on the tooth during formation will remain for the life of that tooth, while stress markers on bone may be erased once the stress is removed. At present, laws concerning removal of antiquities from Egypt and the analysis of human remains (Egyptian Law No. 117 of 1983) prevent stable isotope or trace element analysis of the Hierakonpolis sample. These biochemical studies are likewise impossible for the Naqada sample due to the non-destructive analysis policy of the Leverhulme Centre for Human Evolutionary Studies in Cambridge, England, where the remains are curated.

Seven dietary indicators are examined here. These are carious lesions, calculus, abscess, periodontal disease, hypoplastic enamel defects, macrowear and microwear. Researchers have verified associations between diet and dental disease throughout the world (e.g., Baaregaard, 1949; Buikstra, 1992; Enwonwu, 1981; Kelley et al., 1991; Walker and Erlandson, 1986). In brief, carious lesions and calculus increase relative to the amount of carbohydrates consumed, which increases dramatically in agricultural diets (e.g., Bang and Kristoffersen, 1972; Christophersen and Pederson, 1939; Cran, 1959; Larsen et al., 1991; Mayhall, 1970; Pederson, 1938; Turner, 1979). If carious lesions or dental macrowear become severe enough to expose the pulp chamber, an abscess may form (Buikstra and Ubelaker, 1994). Like caries, periodontal disease is the result of activities of oral bacteria, but requires the formation of calculus to expose the periodontal tissue to bacteria (Neely et al., 2001). Linear enamel hypoplasias give an indication of overall childhood health, including certain aspects related to diet (Buikstra and Ubelaker, 1994; Goodman and Armelagos, 1980; Goodman et al., 1984a; Goodman and Rose, 1990), and while dental wear is not a pathological condition, it too may reveal much about diet and is thus often studied in conjunction with the aforementioned conditions. Macrowear results from grinding of crowns against one another and contact with food, cheeks and tongue (Hillson, 1986). Macrowear becomes increasingly prevalent in coarse diets. Microwear, like macrowear, is created by the mastication of food particles as well as non-food items (such as sand or grit) that come into contact with the teeth (Teaford, 1991; 1994). All of these conditions are described in detail in Chapter Five.

Objectives

Many of the research questions of this dissertation are largely exploratory. The description of the diet and dental health among the working class Predynastic Egyptians is important beyond hypothesis testing, as little dental research has been conducted on these populations. In this dissertation the following research questions are addressed: What combination of dietary indicators is the most beneficial for establishing an overall picture of diet and dental health? Of the known edible flora and fauna of Predynastic Egypt, what where the working class Egyptians eating? Were the foods found as burial offerings being eaten by the living? Are the diets of the working class at Hierakonpolis and Naqada similar or different?

There is a great deal of information in the literature concerning what food resources may have been available in Predynastic Egypt. However, as outlined in Chapter Two, this information comes almost exclusively from food remains or cultural material, such as artifacts related to food acquisition and production rather than human biological remains. Unfortunately, food remains in the archaeological record are often insufficient to accurately reflect diet, as preservation is often biased and incomplete. Moreover, studies that do address diet based on human biological remains tend to focus on the Dynastic period over the Predynastic due to the relative scarcity of Predynastic samples (e.g., Harris and Ponitz, 1980; Koritzer, 1968; Leek, 1984; Ruffer, 1920; Smith and Dawson, 1924; Smith, 1986c; Strouhal, 1984). The present study addresses these shortcomings in three ways.

Seven indicators of diet were examined in 364 dentitions from working class cemeteries at two Predynastic Egyptian sites: Hierakonpolis and Naqada. The author participated in the excavation of approximately half of the sample from Hierakonpolis, which allowed data to be recorded before the remains were disturbed. Fragments of teeth were collected that may have been missed by those not trained in dental anatomy.

Statistical analyses are used to examine differences in the presence and severity of each dietary indicator between males and females of different age classes at each site. An undertaking of this type and scale has never been attempted for Predynastic Egyptians. The data will help fill the void in studies of Egyptian dental pathology and provide a useful basis of comparison for future studies.

Second, the seven dietary indicators are used to look for statistically significant differences between samples from the two sites. A determination of whether inhabitants of these two large urban centers consumed the same type of diet, with similar food preparation techniques contributes to the discussion of how culturally similar the working class inhabitants of the sites were. The findings of this study will provide future researchers with an expected diet with which to compare their own results. Smaller farmsteads in Upper Egypt were most likely dependent upon either Hierakonpolis or Naqada. Dietary reconstruction, when used in conjunction with archaeological material may aid in determinations of relationships between these urban centers and smaller farmsteads.

Third, dietary indicators are weighed against food resources known to exist during the Predynastic. The results are used to suggest which of those resources most likely comprised the diet of the working class Predynastic Egyptians. This dietary reconstruction provides better insight into the lifeways of Predynastic Egyptians and the importance placed on different food items. For example, the data show whether certain food items found as burial offerings were also key components in the diets of the living, and whether plant and animal remains found in habitation areas were actually used as food or had some other, non-dietary function.

A greater amount of information on dental pathologies in Predynastic Egypt may make possible more concrete statements about diet at that time, and provide through inference, information concerning social structure, economy, and inter-group contact. The wide array of dietary indicators mentioned above are used in this study, as is existing information about the available ecological resources (flora and fauna), to reconstruct dietary habits and differences at Predynastic Hierakonpolis and Naqada.

Hypotheses and Research Questions

In this study three working hypotheses are tested. These are: (1) that all members within the working class had equal access to food resources; (2) that the edible plant and animal remains found as burial offerings and in habitation areas were actually being consumed; and (3) that members of the working class from both Hierakonpolis and Naqada maintained similar diets. The results of these tests provide a means to answer the larger research questions described above.

By testing for differences in diet and dental health within each sample, this study shows whether males, females and juveniles consumed the same diet, or whether certain sub-sets (e.g., gender, age class, etc.) of the working class population had differential access to certain food types. The implications of differential access to food resources reach far beyond diet itself. Because diet plays a major role in the etiology of many diseases, differential access to food resources may contribute to the epidemiology of certain diseases seen among Predynastic Egyptians. As sex inequalities are often difficult to distinguish via material culture (Meskell, 1999), dietary differences provide one avenue of determining social relations and family organization. In studying a sample of this nature, it is vital to go beyond basic data description to place the sample in a broader context. Thus, the working hypotheses described above are used to test four major research questions.

Research Question One

What combination of dietary indicators is the most beneficial for establishing an overall picture of diet and dental health among these populations? This portion of the dissertation is largely exploratory. There are no previous studies that employ as wide an array of dietary indicators to as large of a sample size for Predynastic Egypt as the present study. Carious lesions, calculus, abscess, periodontitis, antemortem tooth loss, macrowear, and microwear are used to reconstruct diet and dental health of each sample. How each individual indicator relates to diet is discussed in more detail in Chapters Five and Six.

Research Questions Two and Three

Of the known edible flora and fauna of Predynastic Egypt, what were the working class Egyptians at Hierakonpolis and Naqada eating? Were the items found as food offerings in burials being consumed by the living? These two questions can be effectively examined together.

Comparisons of the available food resources to the dietary indicators reveal the composition of the diet of working class Predynastic Egyptians. Although there is archaeological evidence for diet, such as vegetal remains found in jars (Hugot, 1968), faunal remains from settlement and midden localities (Banks, 1989; McArdle, 1987; Wendorf et al., 1989), artistic representation of food (Shaw, 1976), and food items used as burial offerings (Mattirolo, 1926), there are potential caveats involved in inferring diet from these. Archaeological evidence of available food items in the Hierakonpolis and Naqada regions are discussed in more detail in Chapter Three. Vegetal and faunal remains are rarely preserved and/or recovered in proportions equivalent to diet (Ambrose, 1993; Wahome, 1990), and some food items may be absent. Indirect evidence of diet, such as artistic representations of food and burial offerings of food, is often misleading, as they may not be directly translatable to actual food consumption, and may make determination of diet difficult (Gabel, 1960; Shaw, 1976). In this study, the human remains are used to interpret diet and dental health. Studying the body as an artifact can show how the individual interacted with the environment and material culture on a daily basis (Meskell, 1997, 1999, 2000).

Research Question Four

How similar is the diet of the working class inhabitants of Hierakonpolis and Naqada? Each site and the relationship between the two site populations are discussed further in Chapter Four. A determination of whether the inhabitants of these two large urban centers consumed the same type of food using similar preparation techniques adds to existing data about cultural similarities/differences of the site populations. Previous studies have used similar dietary indicators to interpret the relationship of samples within a site (Greene, 2000; e.g., Ibrahim, 1987) and between sites (Ibrahim, 1987; Schmidt, 1998; e.g., Sciulli and Schneider, 1986).

Biological differences between the two groups were not found through dental non-metric trait analysis (Irish, 2005). There is evidence, however, that these two centers engaged in warfare (Holmes, 1989a). Although modern thought views these two groups as being part of the same ethnic group, ethnic identities are shaped by historical context and are often contested, manipulated and overlapping (Smith, 2003; Stein, 1999). Dietary comparisons of the working class of these two populations in conjunction with biological affinity studies and archaeological data may help answer questions about the political, economic and interpersonal interactions of Hierakonpolis and Naqada.

Significance

There is a relative lack of studies focusing on the biological anthropology of the region and time period studied here. Information concerning the habitation, architecture, ceramics, tool assemblages and personal adornment of the Predynastic Egyptians is readily available (Adams, 1988; Bard, 1999; Hassan, 1988a; Midant-Reynes, 2000a; Needler, 1984; Shaw, 2000a). Despite the fact that most of this information has come from cemeteries, relatively little is known about the biological anthropology and far less still about the dental anthropology of individuals from this time period. In 1972, Greene (1972:315) stated that the study of Egyptian dental anthropology was based upon "…a few published reports dealing with a small portion of the data." The most recent comprehensive literature review of the "Dental Anthropology of the Nile Valley" by Rose and coworkers (1993) cites fewer than 30 entries in the bibliography dealing specifically with dental pathologies of Egypt or Nubia.

Studies of the dental pathologies of ancient Egyptians are generally focused on the Dynastic period (e.g., Harris and Ponitz, 1980; Koritzer, 1968; Leek, 1984; Ruffer, 1920; Smith and Dawson, 1924; Smith, 1986c; Strouhal, 1984) due to a relative lack of Predynastic samples. Many studies are purely descriptive, which makes statistical comparison of the data arduous (Leigh, 1934; Podzorski, 1990; Ruffer, 1913; Sach, 1927; Satinoff, 1968; Turner and Bennet, 1913). Statistical analysis was first applied to dental anthropology in the late 1960s. In fact, research in the 1960s and later provide most of what is known about dental disease in ancient Egypt. There is still a less than an adequate picture of the diet and/or dental health of Predynastic Egyptians. For example, only three studies of dental pathology in Predynastic Egypt list statistical differences between the sexes (Ibrahim, 1987; Leek, 1984; Strouhal, 1984). Despite excavation of an estimated 20,000 graves from approximately 65 Predynastic cemeteries between 1890 and 1920, analysis of much of the skeletal material from these cemeteries is not possible as the remains were not retained and their location is currently unknown. Recent studies have only been possible due to renewed interest in Predynastic mortuary remains and new excavations (Friedman, pers. comm. 2006).

This is the first dental study to examine a statistically significant sample of individuals from two contemporaneous populations of Predynastic working class Egyptians using multiple dietary indicators. Other studies have used fewer individuals, single dietary indicators, or are primarily descriptive (Grilletto, 1973; Hillson, 1978; Ibrahim, 1987; e.g., Leek, 1966; Podzorski, 1990; Strouhal, 1984). Thus, existing hypotheses about the diet of Predynastic Egyptians that have been proposed based on archaeological evidence of available foodstuffs are tested here (Brewer and Friedman, 1990; Clark, 1971; el Hadidi, 1982; Hassan, 1988a; Krzyzaniak, 1988; Leek, 1972; McArdle, 1992; Morcos and Morcos, 1977; Murray, 2000b; e.g., Ruffer, 1919; Saffiro, 1969; Shaw, 1976).

Second, the study of Hierakonpolis and Naqada provides a unique opportunity to examine individuals from the same social class as determined through cemetery location, rather than number of grave goods, which may be altered through centuries of looting. While cemeteries at smaller sites in Egypt are typically not segregated with respect to wealth or status, those at large towns (e.g., Hierakonpolis and Naqada) exhibit social stratification in geographically separate burial locations. Comparison of the working class diet of these two populations, in conjunction with biological affinity studies (Irish, 2005), may help shed some light on debates about the biological and cultural similarities between the two populations. This is discussed in Chapter Four. Thus, this study provides an additional data set to existing archaeological evidence about the degree of interaction between inhabitants of these two sites (e.g., Bard, 1994b; Friedman, 1994; Griswold, 1992; Hassan, 1988b; Holmes, 1989a; Kemp, 1989; Wilkinson, 1999).

Finally, the scope of the indicators and sample size used in this study is uniquely robust. A thorough literature review suggests that this is the first study to use all of these dietary indicators concurrently. Not only does this study provide a more detailed picture of the diet and dental health of the working class of Predynastic Egypt than currently exists, it is also methodologically useful to the study of diet in other world regions by showing the relationship and possible interactions of numerous dietary indicators. Sample sizes in this study are among the largest published for any region for many dietary indicators and are, thus far, the largest ever used for microwear analysis. Analysis of these numerous dentitions is also significant for the sub-field of dental microwear analysis.

Chapter One listed the goals and significance of this study. Each of the above ideas are explored further throughout this dissertation. The following paragraphs summarize the subsequent chapters.

A general overview of the Predynastic is provided in Chapter Two, including the chronology of the Predynastic period and discussion of life in each Predynastic phase. This chapter shows how the Naqada II culture, used in this dissertation, developed. Naqada II was a time of great change leading into the unification of Upper Egypt in early Naqada III.

Chapter Three describes the food resources that may have been available during the Predynastic based on faunal and floral remains, indirect archaeological evidence, and nutritional deficiencies seen on skeletal remains. This chapter also includes a discussion of the climate in Egypt, as the climate often dictates what foods are available.

Specific descriptions of the two sites used in this study, Hierakonpolis and Naqada, are given in Chapter Four. This chapter details what has been discovered archaeologically at each site including settlements, cemeteries, food remains, and evidence of trade. Previously established theories about the relationship between the two populations are also discussed.

Etiologies of the dental pathologies and their prevalence in Predynastic Egypt are given in Chapter Five. Although not pathological, dental calculus is also included in Chapter Five along with carious lesions, abscess, periodontal disease, and linear enamel hypoplasia.

Chapter Six describes the formation and significance of dental macrowear and microwear. This chapter discusses how macrowear and microwear can be used in dietary reconstruction and what is known from previous studies on Predynastic Egypt.

Chapter Seven explains the materials used in this project and the methods employed to answer the questions posed by this study. Details are given for the nature of each sample, the methods of data collection and the methods of statistical analysis, including a summary of the utility of the statistical tests used.

The results of the study are listed in Chapter Eight. Results are given for differences between males and females of each sample and for differences between the samples. Tables are provided showing the means for each of the dietary indicators studied for males and females of each age group as well as the level of significance (p value) between the groups examined.

Chapter Nine provides an interpretation of the results. First, the dental health and dietary inferences of each sample are discussed separately. The dental health and diet of the people who lived at the two sites are then compared and contrasted.

Chapter Ten provides an overall summary of the project. Major research questions examined and the working hypotheses used to test these questions are reviewed in this chapter. How the data from this study support the working hypotheses and contribute to the broader research questions are also discussed. Lastly, this chapter outlines the contributions made by this dissertation and possible directions for future research.

CHAPTER TWO

PREDYNASTIC EGYPT

The Predynastic period begins with the appearance of farming communities (Bard, 1999) and ends with the unification of Egypt (Adams, 1988; Bard, 1999; Friedman, 1994). It is comprised of three phases: Naqada I (4000-3500BC), Naqada II (3500-3200 BC) and Naqada IIIa (3200-3100 BC). Over this period, Egypt progressed from small isolated farming communities to larger, increasingly complex societies (Bard, 1994a; Friedman, 1994). However, the manner and timing of these changes were not consistent throughout Egypt. There were vast differences in the environment, material culture and chronological development of populated areas in Upper (Southern, upstream) Egypt and Lower (Northern, downstream) Egypt (Adams, 1988; Bard, 1999; Holmes, 1992b).

The sites used for this study, Hierakonpolis and Naqada, are located in Upper Egypt, and here all references to Predynastic Egypt pertain to Upper Egypt only. In the Predynastic, Upper Egypt extended from modern day Aswan to Gerzeh, which is approximately at the Fayum (Kemp, 1989) (refer to Figure 2.1). For a comprehensive review of the archaeology and development of Lower Egypt in the Predynastic period see Bard (1987b; 1994a), Brewer (1989), Caton-Thompson (1934), Midant-Reynes (2000b) and Wenke (1992), among others.

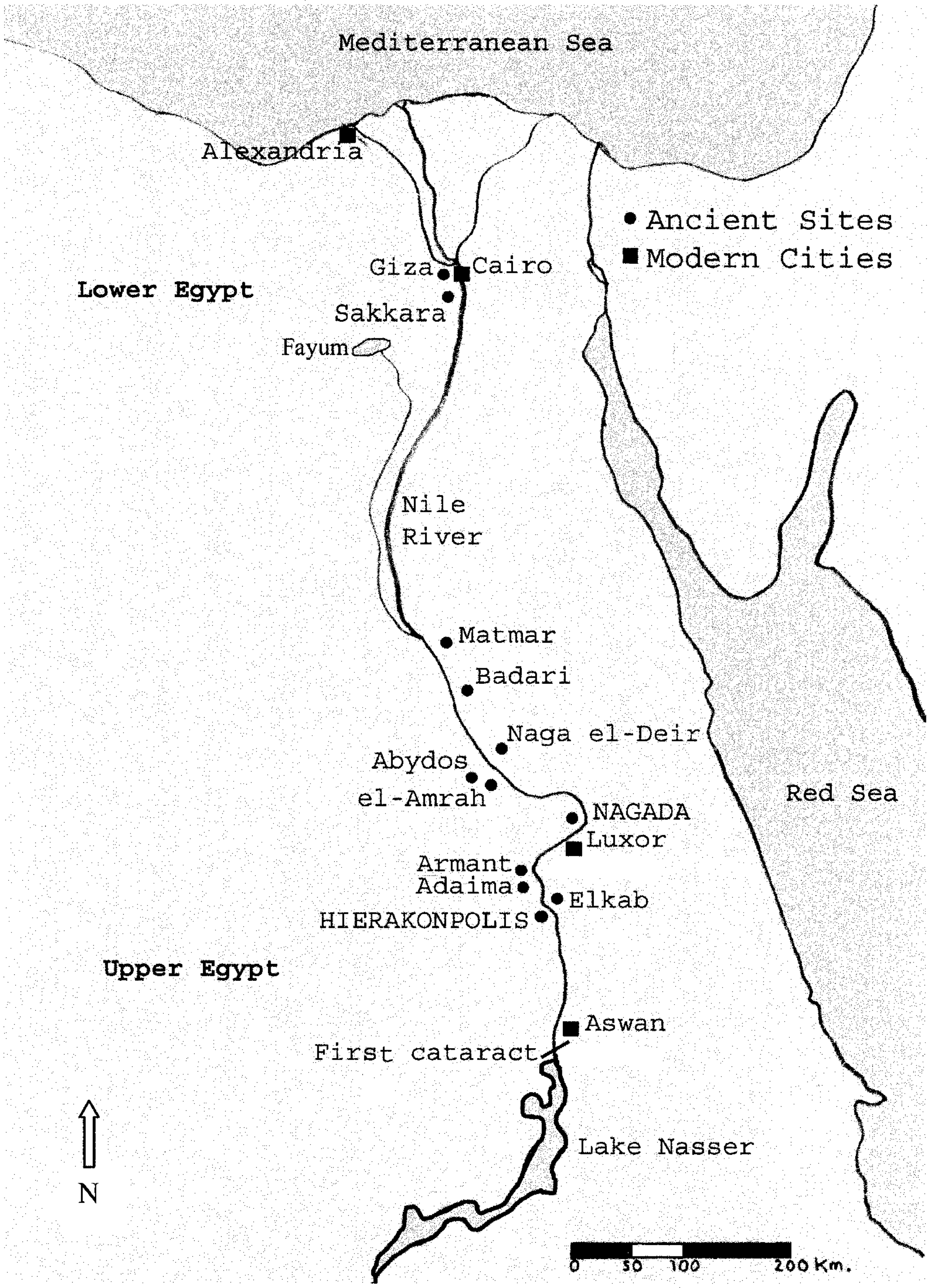

Figure 2.1: Map of Egypt. (Adapted from the Oriental Institute Series, 2005.)

Chronology

Several chronologies exist for Predynastic Egypt. Table 2.1 provides a comparison of some of these. W.M.F. Petrie was the first to construct a relative chronology of Upper Egypt (Petrie, 1899; Petrie and Mace, 1901; Petrie, 1920). Petrie's sequence dating (SD) was based on seriation of ceramics found in graves at Naqada, Ballas and Diospolis Parva. The Predynastic culture in Upper Egypt is also known as the Naqada culture, because the majority of the graves Petrie studied came from the Naqada site, the first recognized Predynastic discovery in Egypt (Petrie 1900, 1901, 1920 in Hendrickx, 1996).

Table 2.1: Chronology of Predynastic Egypt. Terminology used throughout this dissertation is in parentheses.

	Other Terms	**Petrie (1921)**	**Kaiser (1957)**	**(Shaw, 2000b)**
	Badarian	Badarian	Badarian	4400BC
Early Predynastic (Naqada I)	Early Amratian Late Amratian	SD 30 - 37	Nagada Ia-b Nagada Ic-d	4000 BC
Middle Predynastic (Naqada II)	Early Gerzean Middle Gerzean Late Gerzean	SD 38-40/45 SD 40/45 - 63	Nagada IIa Nagada IIb Nagada IIc Nagada IId	3500 BC
Late Predynastic	 Semainean	SD 60/63 – 80 SD 60 – 75	Nagada IIIa	
Protodynastic (Naqada III)	Dynasty 0	SD 76 - 78	Naqada IIIb	3200 BC

Realizing there may be pottery styles yet unidentified, Petrie started numbering at 30 to leave room for earlier types to be added upon discovery. Petrie divided the sequence dates into three 'cultures', which he called Amratian (SD 30-37), Gerzean (SD

38-60) and Semainean (SD 60-75) (Hendrickx, 1996). Table 2.1 relates these to period names currently used.

Although no one has contradicted Petrie's general ideas about the development of Naqada culture, it is apparent that the sequence dating required more precise methods not available at that time (Hendrickx, 1996). However some authors continue to list the sequence dates parenthetically alongside dates generated by more conventional methods (i.e. radiocarbon dates).

Kaiser's (1957) chronology was initially based on spatial distribution of pottery classes and types of objects within the cemetery 1400-1500 at Armant. Kaiser defined three zones that he considered a chronological stage in the development of the Naqada culture; Naqada I (4000-3500 BC), Naqada II (3500-3200 BC) and Naqada III (3200-3000 BC). Kaiser further divided Naqada I, II, and III into eleven sub-periods, called Stufen, based on the clustering of types of objects, particularly pottery. These phases and sub-periods are the most common terms used today.

Recently, researchers have added the use of the radiocarbon method to the determination of Egyptian chronology. Absolute methods have provided the following dates: Naqada Ia-IIb (3900-3650 BC), Naqada IIc-IID2 (3650-3300 BC), Naqada IIIa1-IIIb (3300-3100 BC), Naqada IIIc1 (3100-3000 BC), Naqada IIId (2900 BC onwards) (Hendrickx, 1996), but while there is a general agreement on a relative Predynastic chronology, the absolute chronology is still debated (Harlan, 1985; Hendrickx, 1996).

The numerous attempts to correct for the problems with past dating techniques have created another difficulty. Even in current literature there are a variety of terms used to refer to the same period. The terms Amratian, Naqada I, SD 30-37 and early Naqada, all correspond to Kaiser's Stufe Ia through IIb. Gerzean, Naqada II, SD 38-60 and late Naqada refer to Kaiser's Stufe IIcd. The term Semainean, applied by Petrie, is no longer used, but corresponds to parts of Kaiser's Stufe III, Naqada III, or the Protodynastic (Geller, 1992a). The terms Early Predynastic, Middle Predynastic and Late Predynastic are also seen, but do not always refer to the same phases. It should be noted that Naqada might also be spelled Nagada (e.g., Bard, 1987a; Castillos, 1979; Drake, 1980; Hassan, 1979; Holmes, 1989b; Lovell and Johnson, 1996; Warren, 1897) or Nakada (Phillipson, 2005).

Origins of Upper Egyptian Populations

Predynastic population origins in Upper Egypt have been debated since the Badarian culture was described by Brunton and Caton-Thompson (1928). Several researchers believe that Badarian populations were not actually Egyptian but came from the east (Hendrickx and Vermeersch, 2000; Krzyzaniak, 1977) or from the south (Arkell, 1975; Brunton and Caton-Thompson, 1928; Keita, 1990). The generally accepted explanation today is that they originated from the Neolithic peoples of Egypt's Western Desert (Hassan, 1988b; Hendrickx and Vermeersch, 2000; Holmes, 1989b; Midant-Reynes, 2000b). Recent affinity studies based on dental morphological traits show that samples from the Neolithic Western Desert differ significantly from all other groups (Irish, 2005). However, a weak affinity with Predynastic and Early Dynastic samples from Abydos, Hierakonpolis, and Badari support idea that there was supplementary influence from the Levant (Hendrickx and Vermeersch, 2000) or Eastern Desert (Holmes, 1989b; Irish, 2005) .

Some researchers believe that the Naqada cultures did not develop out of the Badarian cultures (Holmes and Friedman, 1989; Keita, 1996; Midant-Reynes, 2000b; Prowse and Lovell, 1996); however, material culture says there was continuity between Badarian and Naqada cultures (Arkell and Ucko, 1965; Brunton, 1932; Fairservis, 1972; Hoffman, 1988; Kantor, 1965; Massoulard, 1949; Midant-Reynes, 2000b; Mond and Myers, 1937). Recent dental affinity studies comparing the people at Badari with those at Naqada and Hierakonpolis support the latter (Irish, 2005). However, Holmes (1989b) suggests that continuity may have existed only in the Badari region and that Naqada peoples elsewhere may have come from Egypt's Western and Eastern deserts.

Lifeways in Predynastic Egypt

Badarian

The Badarian culture dates from approximately 4400 – 4000 BC and may have existed as early as 5000 BC. Although less is known about this, as compared to subsequent cultures, it generally marks the beginning of the Predynastic period and leads into the Naqada period (Midant-Reynes, 2000b). The first evidence of agriculture in Upper Egypt begins in the Badarian and includes wheat, barley, lentils and tubers (Watterson, 1997). There is also evidence for domesticated goats and sheep (Midant-Reynes, 2000b).

While Badarian was first identified in the el-Badari region, sites are located farther south at Hierakonpolis and east in Wadi Hammamat (Hendrickx and Vermeersch, 2000) (Figure 2.1). Settlements appear to have been small villages that moved after short periods of occupation (Hendrickx and Vermeersch, 2000). Village populations most likely consisted of no more than a hundred or so individuals at any given time (Hoffman et al., 1986).

Graves from this period tended to be located within settlements, often in parts that were no longer in use for occupation. All known graves are simple, pit burials of a single individual (Hendrickx and Vermeersch, 2000; Midant-Reynes, 2000b). Most are oval, but round graves are not uncommon (Castillos, 1982). Bodies are typically in a flexed position, on the left side, with the head to the south and facing west (Brunton and Caton-Thompson, 1928; Castillos, 1982; Hendrickx and Vermeersch, 2000). Mats were often placed under, and sometimes over, the bodies. Occasionally, bodies are found covered or wrapped with an animal hide (Midant-Reynes, 2000b).

Naqada I

Naqada I culture (4000 – 3500BC) initially differed only slightly from the Badarian; however, considerable changes occurred during this period (Midant-Reynes, 2000a). Domesticated animals associated with Naqada I include goats and sheep, as in the Badarian, but also bovids, pigs (Darby et al., 1977; Midant-Reynes, 2000a) and donkeys (Hoffman, 1989a). There is evidence for cultivation of barley, wheat, peas, and tares and Naqada I populations also consumed fruits from the jujube and a possible ancestor of the watermelon (Midant-Reynes, 2000a). Wild fauna such as gazelles and fish were initially an important part of the diet but became rare by the middle of Naqada I (Midant-Reynes, 2000a; Watterson, 1997; Wetterstrom, 1993).

House structures from Naqada I consisted of a mixture of mud and organic material, such as wood, reed and palm (Midant-Reynes, 2000a), although building material and dwelling style were not consistent throughout Upper Egypt. Roofing material does not survive, which suggests more fragile plant material was used for roofing (Watterson, 1997). At Hierakonpolis, along with the more common circular houses, there is evidence of rectangular, semi-subterranean house structures. One such dwelling measures 4.0 m by 3.5 m (Hoffman, 1980). Some houses had an open 'barnyard' around the houses. Other houses shared common walls that had foundations of small stones held together with mud (Hoffman, 1989b). It has been proposed that dwelling style may have been determined by wealth or social status. Thus, the diversity in dwelling types suggests some economic and social variability that began to develop during Naqada I (Midant-Reynes, 2000b).

As in the Badarian, graves tend to be simple oval pits, with bodies in a flexed position on the left side, head to the south and facing west (Castillos, 1982; Midant-Reynes, 2000a). The practice of wrapping or covering the body in animal skin is less common and sometimes replaced with a wood coffin (Midant-Reynes, 2000b). Mats were still placed below the body and some individuals received a pillow of straw or leather. While little cloth has survived, there is some evidence of fabric or leather loincloths (Midant-Reynes, 2000a).

Although most burials contain single individuals, multiple burials are becoming more frequent (Castillos, 1982) and while some 'richer' (artifact rich) graves cluster together during the Badarian, in Naqada I there is greater differentiation in burial customs. This is especially true at larger sites such as Hierakonpolis and Naqada. At the end of Naqada I, the appearance of large tombs suggests the growth of an elite class at several sites. While most individuals are buried in small oval pits, a few individuals are found in richer, larger, typically rectangular graves segregated from the rest of the cemetery (Friedman, 1994; Midant-Reynes, 2000b). These larger tombs are evident at Abydos Cemetery U, Hierakonpolis at Cemetery HK6, and at Cemetery T at Naqada. Larger, richer graves indicate increasing social differentiation - some have suggested the emergence of a class of chiefs (Midant-Reynes, 2000b).

There is also evidence that specialized workshops developed during Naqada I. Ceramics (Friedman, 1994) and lithics (Holmes, 1989a) from Naqada I show evidence of regional variations. Blade workshops at Armant are located near deposits of Theban chert, while production of tools was local (Ginter et al., 1996). Techniques for working both hard and soft stones were developed. The first mace-heads appear (Midant-Reynes, 2000a). There are more metal artifacts including, copper pins, harpoons, beads and bracelets (Midant-Reynes, 2000a). The first Egyptian faience developed. Faience is a paste made of crushed quartz and copper which can be molded and then fired and typically used as jewelry or decoration (Midant-Reynes, 2000b).

Naqada II

Naqada II (3500-3200 BC) is the focus of this study. While it was once believed that the transition from Naqada I to Naqada II took place following an Asiatic invasion, it is now recognized that the transition was more gradual and continuous (Ruffle, 1977). Fundamental changes in material culture and funerary practices in Naqada II develop from Naqada I, there is no sudden break (Midant-Reynes, 2000a).

Kaiser (1957) differentiated Naqada I from Naqada II by the appearance of 'rough' pottery within burials. This period is marked by an expansion of the people and material culture northwards toward the Delta and south as far as Nubia. There is also evidence for contacts with Southwest Asia (Friedman, 1994).

Naqada II is a time of great cultural change including an increase in social differentiation and increased political and economic complexity as evidenced the appearance of distinct habitation, burial, ceremonial/administrative, and industrial zones, as well as indications of specialized production and differential accumulation of wealth (Bard, 1994a; Geller, 1992a; Midant-Reynes, 2000b; Takamiya, 2004).

People of Naqada II were almost fully dependent on agriculture and animal husbandry (Wetterstrom, 1993). Domesticated livestock included cattle, goats, sheep, and pigs. There were also domesticated dogs that were afforded a special status as reflected by their burials within the settlement of Adaima. Hunting of large mammals such as hippopotami, gazelle and lions gradually became socially restricted until only the elite groups participated. Fish remained an important part of diet (Midant-Reynes, 2000a).

While there is evidence for farming of several different species, very little evidence of wild plant foods exists (Wetterstrom, 1993).

Depletion of tamarisk and acacia, burned during pottery manufacture, most likely placed a strain on the desert ecosystem. At the same time, climatic shifts caused a decline in average Nile flood height. A depleted desert ecosystem together with the increased distance between the desert farms and the water source would have encouraged farming of the highly productive Nile floodplain (Hoffman et al., 1986). Reliance on farming would have had the additional benefit of decreasing the dependence on less predictable wild foods (Wetterstrom, 1993). As agriculture continued to increase during Naqada II, the populations grew denser and more permanently settled, as allowed by the now local and more predictable food source (Midant-Reynes, 2000b).

Settlements grew larger and eventually consisted of strings of villages clustered near the river, along the entire Nile valley (Midant-Reynes, 2000a). Populations continued to become more dense throughout Naqada II (Hoffman et al., 1986). Mud and plant matter lost popularity as the dominant building materials, as more permanent structures were established. Large rectangular structures with stone foundations were typical of Naqada II. By the end of Naqada II, people began to surround their towns with massive walls (Midant-Reynes, 2000b).

Larger, more permanent settlements led to the opportunity for craft specialization, such as food producers, lithic workshops, pottery makers, etc (Midant-Reynes, 2000b; Takamiya, 2004) and evidenced by production sites and high levels of manufacturing technology (Takamiya, 2004). Denser populations with specialized workers appears to have required more effective organization of the economy at large cities such as Hierakonpolis and Naqada (Hoffman, 1979). Some items that required specialized workers, such as decorated pottery vessels and ripple-flaked knives were used as luxury items or displays of wealth, thus illustrating status differences (Takamiya, 2004).

Evidence for increasing social differentiation is most prominent in the burials. These class distinctions became more pronounced over time. In the early part of Naqada II (a/b) there is evidence of at least two social groups: rich and poor (Friedman, 1994). Social hierarchy is evidenced by the quantity and variation in materials and types of artifacts, burial architecture, and location of the burials (Rowland, 2004). In the later part of Naqada II (c/d) an even more complex social system is evidenced by a greater diversity in burials (Friedman, 1994). While wealth does not necessarily relate to social status in many parts of the world (Bendix and Lipset, 1966; Cohen and Middleton, 1967) status and wealth have been shown to be highly correlated in ancient Egypt (Bard, 1987a, 1989; Castillos, 1982; Ellis, 1996; Friedman, 1994; Rowland, 2004).

Cemeteries associated with Naqada II contain an ever widening range of grave types, from small oval or round pits with few offerings to large rectangular pits with mud-brick partitions forming separate compartments for offerings (Midant-Reynes, 2000a). Tomb interments are proportionally rarer relative to Naqada I; however, those that do exist are larger, more elaborately constructed, and contain fewer, although more rare grave goods (Midant-Reynes, 2000b). By the end of Naqada II, elite tombs measured as large as 5 m by 3 m (Payne, 1973).

Rectangular graves increase by approximately six percent in Naqada II relative to Naqada I (Castillos, 1982; Midant-Reynes, 2000b). These tend to be larger and wealthier (more grave goods) than the round or oval graves (Friedman, 1994). In the later part of Naqada II, some of the rectangular graves were lined with mud and mud-brick. From early Naqada II, people of different status were segregated at large sites like Hierakonpolis and Naqada, with wealthy cemeteries, such as HK6 at Hierakonpolis and Cemetery T at Naqada, located away from poorer cemeteries (Davis, 1983b; Friedman, 1994).

In general, bodies continued to be buried in a contracted position with the head to the south, facing west. However the exact positioning varies among cemeteries, increasingly more exceptions are found over time (Castillos, 1982; Midant-Reynes, 2000b). While the majority of graves are single, double burials become more common in certain regions, with one grave at Naqada containing five individuals (Midant-Reynes, 2000a). Wood and air-dried clay coffins, which first appear in Naqada I, continue to be used in as many as six percent of all graves (Castillos, 1982; Midant-Reynes, 2000a).

Funerary objects are placed more deliberately in relation to the body in poorer graves; Ceramic jars near the feet with smaller objects such as ivory pins, cosmetic pallets or stone vessels near the head (Geller, 1992a). Placing of certain objects in cubbyholes or compartments of wealthier graves led to increasingly elaborate tomb construction, with the use of earth, wood and mud brick. Separation of grave goods from the body became progressively more accentuated during Naqada II (Midant-Reynes, 2000b) and pre-burial disarticulation (Naqada, Adaima) and the wrapping of bodies in strips of linen (Hierakonpolis) appear for the first time (Friedman, 1999; Midant-Reynes, 2000a).

The increasing diversity in funerary arrangements, including grave type and size, amount and quality of grave goods and types of body wrappings and coffins during Naqada II, suggests an increasing diversity and hierarchy of social structure (Midant-Reynes, 2000b). Social hierarchy was suggested by Davis (1983a) who found the burials of artists and craftsmen at Naqada were clearly differentiated by their distinctive grave goods and were removed from the main cemetery.

Pottery types also reveal the degree of change that occurred during Naqada II. While a few pottery types continued from Naqada I, they tend to disappear by Naqada IIb (Friedman, 1994, 2000; Hassan, 1988b). Two new pottery types appear during Naqada II: 'rough' ware and 'marl' ware. Rough ware appeared at the beginning of Naqada II and is though to be a result of outside influences based on analysis of clay type, temper, texture, porosity, and hardness (Friedman, 1994). While regional variation in domestic pottery existed in Naqada I, rough ware is identical in "temper, manufacturing technique and shape at all sites" (Friedman, 1994:10). At first the rough ware had pointed or rounded bases, but acquired a flat base by the end of the period. Marl ware was made partly from calcareous clay derived from the desert wadis and added to Nile silts. Marl ware appeared at the beginning of Naqada IIb and is believed to indicate a better knowledge of the environment (Friedman, 1994, 2000; Midant-Reynes, 2000a, b).

Some pottery designs were representational, while others were geometrical. The representational designs were usually boats, which represented both a mode of travel and a status symbol (Hassan, 1988b; Midant-Reynes, 2000a). Geometrical designs included triangles, chevrons, spirals, check patterns and wavy lines (Midant-Reynes, 2000a). Spirals appeared in Naqada IIb, followed by figurative scenes in Naqada IIc. As quickly as they appeared, decorated types began to diminish in frequency until they disappeared completely in Nagada III (Friedman, 1994, 2000; Midant-Reynes, 2000b). Wavy handles appear suddenly in the middle of Naqada II and represent the a foreign influence from Palestine (Midant-Reynes, 2000b).

Contact with Nubia is inferred from the appearance of 'Nubian' pottery in the south. Nubian pottery has a silty fabric tempered with either animal dung or ash. A low firing temperature makes it lighter and more porous than Egyptian pottery (Midant-Reynes, 2000b). Other foreign contacts are evidenced by imitations or actual imports of foreign pottery and the use of certain artistic motifs (Kantor, 1993).

There were considerable advances in stone working during Naqada II. Lithic artifacts indicate that stone tool manufacturers during Naqada II were aware of different qualities of the cherts and selected specific types for certain methods of manufacture. Flint knappers used a combination of percussion, pressure-flaking and polishing techniques (Midant-Reynes, 2000b). The Naqada site shows evidence of temporary variations within a very specific local industry during Naqada II (Holmes, 1989b).

Approximately 15% of lithics at Naqada and five percent of lithics at Hierakonpolis were blades or bladelets, many of which were heat treated and tended not to have straight edges (Holmes, 1989b; 1992a). Excavators have found several hundred microdrills that manufacturers apparently used to make stone beads. Other tool classes included circular scrapers, denticulates, perforators, sickle blades, side-scrapers and transverse arrowheads (Holmes, 1992b; Vermeersch et al., 2004). Bone tools, mostly of gazelle metapodials and sheep/goat metacarpals and metatarsals, have been found at El Abadiya in the Naqada region (Vermeersch et al., 2004).

Stone working flourished during Naqada II. Lithic manufacturers used stones from the Nile valley as well as the desert, particularly from the Wadi Hammammat and included limestone, alabaster, marble, serpentine, basalt, breccia, gneiss, diorite and gabbro. There was an increase in the number of stone jars which were also imitated by pottery forms (Midant-Reynes, 2000b). Unlike the pottery they represent, stone vessels could not have been used for day-to-day activities. Instead, stone vessels were a luxury item, perhaps utilized only by certain social classes (Rizkana and Seeher, 1988:56). The skill required to manufacture these stone vessels and the number of vessels made suggests they were made in specialized workshops (Midant-Reynes, 2000b).

The use of copper increased and began to replace certain items previously made of stone, including axes, blades, bracelets and rings (Midant-Reynes, 2000a). A greater range of copper artifacts was possible because copper was now not only hammered but forged (Alimen, 1957). The ability to process metal ores in this way may suggest the mobilization of labor forces by higher status individuals as well as the emergence of a group of 'non-producers', individuals who do not produce food or other goods (Midant-Reynes, 2000b).

At the same time, the use of gold and silver increased. Silver items included rings, beads, spoons and knives. Beads and pendants were made of gold (Baumgartel, 1960).

Some researchers have suggested that the attraction of these metals may account for much of the grave robbery that occurred during the Predynastic (Midant-Reynes, 2000a).

Naqada II culture must have had an economy that supported non self-sufficient craft workers for at least part of the year. Craft workers would have required specialized workshops, which may have also functioned as the places where those crafts were designed and taught (Midant-Reynes, 2000b). Urban centers must have existed for exchange of these specialized crafts. Naqada, Hierakonpolis and to a lesser extent, Abydos, functioned as such urban centers (Midant-Reynes, 2000a). Workers may have had a certain amount of prestige depending upon their craft. However, there could have been no more than a few hundred 'non-producing' craft-workers in the large urban centers, as each one would have required the support of at least 50 agricultural 'producers' (Midant-Reynes, 2000b).

Regional variations in both ceramic (Friedman, 1994, 2000) and lithic (Holmes, 1989b) assemblages revealed during Naqada I disappear by Naqada IIb/c. Disintegration of regional differences may suggest different socio-political units present during the early Predynastic (Friedman, 1994) were joined or were at least communicating or sharing ideas. However, another possibility is that groups were stealing goods or ideas from one another.

Naqada III

The last phase of the Predynastic, Naqada III, also called Protodynastic or Dynasty 0, dates from 3200 – 3000 BC. The Protodynastic was a transitional phase between Naqada II and the 1st Dynasty. During Naqada III, previous trends toward centralization continued and led to the consolidation of Upper Egypt under one rule. A united Upper Egypt laid the foundation for political unification of Upper and Lower Egypt (Bard, 2000; Hoffman et al., 1986). By early Naqada III, artifacts derived from the Naqada culture of Upper Egypt had replaced the material culture of Lower Egypt (Bard, 2000).

Settlements continued to grow and included monumental architecture such as large palace and temple complexes. The majority of the population had moved toward the river valley and/or into large, fortified urban centers, while desert settlements continued to decline (Hoffman et al., 1986). Reliance on urban centers created a nearly complete abandonment of pastoralism and an intensification of agriculture (Midant-Reynes, 2000b).

Increases in social hierarchy are evident in the burials of Naqada III, which are so different from previous periods that scholars initially believed them to belong to an entirely different culture (Bard, 2000). A new level of social complexity, termed the royal elite, is evidenced by grave UJ at Abydos (Friedman, 1994). Graves of elite individuals contained large quantities of grave goods, often made from exotic material such as gold and lapis lazuli (Bard, 2000). Most graves from Naqada III were rectangular, with only about 12% being oval. The majority was still oriented with the head south facing west; however, other orientations become more common, as were multiple inhumations. Coffin use was now seen in 66% of all burials (Castillos, 1982). Decreasing quality of ceramics and slate palettes in most graves is interpreted as evidence of mass production of goods (Friedman, 1994).

CHAPTER THREE

ECOLOGY OF ANCIENT EGYPT

In Egypt and Nubia the Nile River profoundly influences plant and animal life as it is virtually the only source of water. Within Egypt, the Nile river and valley travel some 800 km north-northwest from the second Cataract in the south to the Mediterranean Sea in the North (Morcos and Morcos, 1977; Seddon, 1968). The floodplain varies widely along the length of the river causing an unequal distribution of plants and animals. Near Aswan, the floodplain is barely wider than the river itself. Further downstream, the floodplain widens up to 23 km in certain locations. Thus, potential for foraging and farming varies markedly along the river valley (Issawi and McCauley, 1993; Wetterstrom, 1993).

Natural levees rise a few meters above the floodplain on either side of the river channel, giving the valley a slightly convex appearance (Wetterstrom, 1993). Low desert terraces, with cliffs rising above them, border the floodplain. The Eastern Desert consists of low rugged mountains, steep scarps and valleys, while the Western Desert is a flat monotonous plain that is mostly barren, save for a few oases. However, as outlined below, the area was not always so barren (Issawi and McCauley, 1993).

Climate and the Nile

Today, Egypt's climate is hyper-arid, with only occasional rain south of the Nile Delta. However, the region has experienced numerous climatic changes over the last 20,000 years. These are summarized in Table 3.1. Like the present day, the period from

20,000 to 12,000 BP was hyper-arid, but experienced cooler temperatures (Wendorf and Schild, 1976; Wetterstrom, 1993). As glaciers retreated at the end of the Pleistocene (15,000-12,000 BP), a dramatic climate shift occurred with the end of the Last Glacial Maximum (LGM) and around 12,500- 12,000 BP temperatures began to grow warmer and rainfall increased. Apart from a global cooling event (Hypsithermal) that brought about drier conditions between 8,000 and 7,500 Bp, precipitation levels remained high through the early to mid-Holocene (12,000 – 5400 BP). Present day drier, warmer conditions began around 5400 BP (Wendorf and Schild, 1980; Wetterstrom, 1993).

Table 3.1: Nile climate changes.

TIME	RAINFALL	TEMPERATURE	NILE
20,000-12,000BP	Hyper-arid	Somewhat cooler than present	Smaller, seasonal
➢ 15,000BP		Growing warmer	
➢ 12,500BP-12,000BP	Increased rainfall		High floods
12,000BP – 5400BP	High rainfall, with 2 short dry intervals	Warmer	Swifter and deeper
5400BP	Became dryer – trend continued to present	Warm	Modern levels
Today	Hyper-arid	Warm	

Over the same period, the Nile has undergone many transformations. Varying water volumes and sediment loads have undoubtedly influenced the regional archaeological record (Paulissen and Vermeersch 1987), and some researchers attribute the lack of archaeological material north of the Qena bend (approximately 60 km North of Luxor) to variations in location and size of the Nile (Paulissen and Vermeersch 1987; Wetterstrom, 1993).

During the late Paleolithic, the Nile was a seasonal, sluggish river, probably consisting of several braided channels. The sediment load was heavy, causing the level of the floodplain south of the Qena bend to gradually rise (Wetterstrom, 1993) and create the dunes (Clark, 1971). Increased rainfall at the end of the Pleistocene caused very high floods that were probably catastrophic, but lasted only a short time. Above Qena bend, beginning around 12,000 BP, the Nile became a single, swifter, deeper river cutting through the valley floor. Nile bedrock shows more horizontal than vertical differentiation, suggesting the river became a great deal wider from the Pleistocene on and probably reached modern levels and widths in pharaonic times (Butzer, 1980).

Together, climatic (end of the LGM) and geological changes resulted in a rich diverse floodplain ecosystem during the Holocene. Monsoonal rains from equatorial Africa traveled further north, bringing summer rains to much of the Sahel and Sahara deserts. Seasonal rains resulted in several moist phases occurring in much of the Sahara. However, not all of Egypt received equal amounts of rain. Southwest Egypt underwent three major moist periods from 10,000 to 8200 BP, 8100 to 7900 BP and 7700 to 5400 BP or later (Wendorf and Schild, 1980:236-240), although rainfall probably never exceeded 300 mm per year in southern Egypt and was most likely less in northern Egypt (Hassan, 1986). The Holocene also saw winter rains in the Red Sea hills (Wetterstrom, 1993)

Long-term trends of higher or lower floods resulted in major ecosystem adjustments in the Nile valley. Lower floods reduced the local carrying capacity of the Delta and the valley. Higher floods led to a wider floodplain, that would eventually support more life, but was probably detrimental initially (Hassan, 1986). Old vegetation communities died out while new ones were slowly established. The dry intervals of the mid-Holocene would have a decline in ecosystem services (Hassan, 1986; Wetterstrom, 1993)

Flora in Ancient Egypt

Relict vegetation on Nile islands supplies information about the plant ecology of the Pleistocene and Holocene Nile valley (see Table 3.2). Most vegetation survived into modern times and tree zones have always been located above the flood line. However, some shrubs, namely tamarisk (*Tamarix africana*) and markh (*Leptadenia pyrotechnica)* thrive on occasionally submerged sandy deposits (Springuel et al., 1991). Meadows of grasses (*Panicum sp)* and sedges (*Cyperus ssp.)* occupied seasonally flooded terrain. Marshes with reeds (*Phragmites sp)*, grassy weeds (*Polygonum sp)* and sedge covered land that was partially submerged year round (Springuel et al., 1991; Wetterstrom, 1993).

Table 3.2: Vegetation types in Upper Egypt.

TIME	LOCATION	VEGETATION TYPES
PLEISTOCENE	Along banks	Tamarisk, sedges, clump grasses
	Savanna and hills	Bush grass
	Desert	No vegetation
HOLOCENE	Valley margins	Marsh vegetation
	Levees	Trees and shrubs
	Desert edge	Tamarisk, markh shrub
	Alluvial flats	Sedge and grass meadow

Known vegetation, from macro and micro plant remains throughout Egypt suggests that during the late Pleistocene the Nile valley was an open landscape of marshes and meadows, with shrubs and trees limited to the valley edge along the cliffs (Wetterstrom, 1993). Dune fields, where desert winds continually swept sand into the wadi, were located above the marshes and meadows. Annual and perennial bush grass flourished in the steppe savanna and escarpment hills (Clark, 1971; el Hadidi, 1982). During the hyper-arid period, the desert beyond the wadi and the Nile valley were devoid of vegetation (Wetterstrom, 1993).

During the Holocene, marshes would have existed in lower areas of the valley margins and in oxbow lakes of abandoned channels. Some sandy soils along the floodplain edge supported meadows with a somewhat different grass flora (Springuel et al., 1991). Grassy meadows suggest the possible availability of more grazing areas than during late Pleistocene times, particularly during the height of the floods (Springuel et al., 1991; Wetterstrom, 1993)

During the Holocene moist phases, vegetation in the Western Desert was most likely limited and concentrated around seasonal playas and sources of underground water. Summer rains allowed seasonal grasses and forbs to flourish, but there was no year-round surface water (Wendorf and Schild, 1984). Humans were forced to concentrate their settlements around the playas and other sources of water. Dry intervals may have forced populations to migrate to the Nile valley (Hassan, 1986; Wetterstrom, 1993).

Before agriculture, possible plant resources would have come from one or more of the following microenvironments: the river itself; fringing forests of the main stream and the mouths of the tributary wadis; the usually dry middle and upper reaches of wadis together with the shallow depressions lying back from the Nile; and the desert steppe

(Clark, 1971). Table 3.3 provides a list of Egypt's edible flora, their first known appearance, and season of harvest.

Table 3.3: Edible flora, first appearance and season of harvest.

First appeared	Common name	Scientific Name	Season
Indigenous	Water lily	*Nympheae lotus; N caerulea*	Autumn
	Yellow Nutsedge	*Cyperus esculentus; C papyrus*	Autumn
	Water lettuce	*Pistia stratiotes*	Winter/summer
	Water chestnuts	*Trapa bispinosa*	Winter
	Reed	*Typha sp.*	Various
	Wattle	*Acacia*	Summer/Autumn
	Jujube/Christ's thorn	*Ziziphus spina-christ*	Autumn
	Caper	*Capparis deciduas*	Autumn
	Edible grass	*Aristida pungens; A plumose*	Summer/Autumn
	Kreb grass	*Eragrostis ssp*	Winter
	Chicory	*Cichorium intybus*	Summer/Autumn
	Cabbage	*Brassica oleracea*	Winter
	Cowpea	*Vigna unguiculata*	Summer
	Okra	*Hibiscus esculentus*	Summer
Late Paleolithic	Barley	*Hordeum sp*	Winter/Spring
	Dom palm	*Hyphaene thebacia*	Autumn
	Club-rush	*Scirpus maritimus; S tuberosus*	Year round
c7000 BP	Dates	*Phoenix dactylifera*	Autumn
	Taro	*Colocasia esculenta*	Winter
Neolithic	Barley (6-row)	*Hordeum hexastichum*	Winter/Spring
	Emmer wheat	*Tritcum dicoccum*	Winter/Spring
	African Lotus	*Celtis australis; C integrifolia*	Autumn
	Green bristlegrass	*Setaria virdis*	Autumn
	Sorghum	*Sorghum sp*	Summer
c5500BP	Onion	*Allium cepa*	Spring
	Bottle gourd	*Lagenaria siceraria*	Autumn
c5000BP	Garlic	*Allium sativum*	Winter/Spring
c4400BP	Calabass	*Lagenaria vulgaris*	Autumn
	Onionweed	*Asphodelus tenuifolius*	Summer
Predynastic	Fig	*Ficus carica; F sycomorus*	3 crops/year
	Melon	*Citrullus vulgaris; C lanatus*	Summer/Autumn
	Cucumber	*Cucumis sativus; C melo*	Summer/Autumn
	Turnip	*Brassica rapa*	Autumn/Winter
	Lentils	*Lens culinaris*	Winter/Spring
	Barley (multi-row)	*Hordeum vulgare*	Winter/Spring
	Chickling vetch	*Lathyrus sativus*	Winter
	Grape	*Vitis vinifera*	Autumn
	Pea	*Pisum sativum*	Winter/Spring
	Date palm	*Phoenix dactylifera*	Autumn

Water Plants

Herodotus wrote of two plants growing along the Nile in the mid 5th century BC. One is the water lily (*Nympheae lotus; Nympheae caerulea*); the other is possibly a sedge (Herodotus, 1954). Water lily rhizome was, and still is, an important source of food in many parts of the world. It may be eaten raw or cooked. Water lily fruit and seeds are also edible. Yellow nutsedge (*Cyperus esculentus)* is native to the Mediterranean and western Asia. It has an edible 'nut', actually a tuber, which is often found in Dynastic tombs (Clark, 1971; Saffiro, 1969) and has been found in Predynastic working class burials from Hierakonpolis (Friedman, 1994). The soft interior parts of the lower end of papyrus (*Cyperus papyrus)* are eaten in times of famine (Saffiro, 1969).

Modern peoples of eastern Sudan eat water lettuce (*Pistia stratiotes*) from the Upper Nile in times of famine. Water chestnuts (*Trapa bispinosa*) are abundant in the Nile system. The Fulani of Adamawa and tribes in northern Nigeria still eat the fruits of the singara nut (*Trapa bispinosa*). Starchy rhizomes of the reed *Typha* sp. are edible and are also used as a fuel in Egypt (Clark, 1971).

Fruits

Trees and shrubs of the fringing forests provided several sources of fruit. Fruit producing trees are determined in part from tomb records and from studies of plant communities along the Nile in the Sudan (Clark, 1971). The following species are indigenous to northeast Africa: Wattle (*Acacia* sp) produces an edible gum often used as a thickener; jujube (*Ziziphus spina-christi)* is a spiny shrub also known as Christ's thorn, which produces a fruit high in vitamin C (Clark, 1971; el Hadidi, 1982; Saffiro, 1969); caper (*Capparis deciduas)* has a similar edible fruit to that of the jujube (Clark, 1971). While still green, Christ's thorn has a very sweet taste, and may be dried and rubbed into a paste.

Among the earliest cultivated fruit trees, dates (*Phoenix dactylifera*) were present in Egypt by 7000 BP (Hugot, 1968; Murray, 2000b; Saffiro, 1969). Date pits have been found in at least seven Predynastic working class burials at Hierakonpolis. The large size of the pits suggest that they had been artificially pollinated (Fahmy, 1998). All parts of the date palm, including the trunk, fronds, stalks, leaf stalks, fiber, flowers, heart, fruit, kernels and sap were exploited but only the fruits are edible (Hugot, 1968). Egyptian plum (*Cordia* sp) and Christ's thorn have also been found in Predynastic working class burials at Hierakonpolis (Friedman, 2004b). African lotus (*Celtis australis, Celtis integrifolia*) has been found in Egyptian Neolithic pots. Lotus kernels have a slightly bitter taste and a crisp pulp that can be made into flour. The whole fruit can be made into wine. A fruit paste can be made by boiling down the pulp (Hugot, 1968).

Vines

Melons and cucumbers are an important source of both food and water in desert environments and were most likely collected and the seeds stored by Nile populations as early as their first known appearance in the Predynastic (Clark, 1971). Cucumbers (*Cucumis melo*) have been found at Hierakonpolis (Fahmy, 2004). Watermelons (*Citrullus vulgaris*) are widespread in the northern Sahara (Hugot, 1968). Intestinal contents of some Predynastic bodies contain watermelon seeds. Grapes (*Vitis* sp.), known from as early as the Predynastic in the Naqada region (Cappers et al., 2004; Murray, 2000b), were among the most important fruits in Dynastic times and probably held similar importance earlier. Tomb illustrations suggest several grape varieties including white, green, pink, red, deep blue and violet. Although grapes were grown mainly for wine making, they were also eaten fresh and dried (Morcos and Morcos, 1977).

Grasses

Several grasses with potential for use are indigenous to the lower and middle reaches of the Nile. Perennial and annual species of bunchgrass (*Aristida ssp)* are well represented and have a wide climate tolerance and distribution. Cereal grains (*A. pungens; A. plumose*) provide some of the best wild food plants for the Hoggar and Tassili n'Ajjer Tuareg in the Sahara desert. Another important grass to peoples of the Sudan belt is Sahara millet *(Panicum turgidum*). Kreb grass (*Eragrostis* ssp) is important throughout the Sahara, is a wild grain that was cultivated during Dynastic times (Clark, 1971). Barnyardgrass *(Enchinochloa* ssp), closely related to millet, is an abundant grain in Egypt (Clark, 1971). Some types of cultivated grass were also found as early as the Neolithic in the Western Dessert including broadleaf signal grass *(Brachiaria* sp), barnyardgrass, Sahara millet, foxtails (*Setaria virdis,*) and sorghum *(Sorghum* sp) (Fahmy, 2004).

Egyptians have cultivated emmer wheat (*Tritcum dicoccum)* and barley (*Hordeum* ssp) at least since the 6th millennium BC (Caton-Thompson and Gardner, 1934; Murray, 2000a; Wetterstrom, 1993) and continued to depend heavily on them until Roman times (Murray, 2000a). Emmer wheat has been found associated with Naqada I settlements in the Naqada region (Cappers et al., 2004; Hassan, 1981; Vermeersch et al., 2004; Wetterstrom, 1993) and at Hierakonpolis. As evidenced by both grains and glume bases, emmer wheat is the predominant cereal grain used at Hierakonpolis(Fahmy, 1995, 1997b, 1999). Emmer wheat was virtually the only type of wheat grown in Egypt; however, durum wheat *(Triticum durum)* has been found in smaller quantities at Hierakonpolis (Fahmy, 1995) and at Predynastic sites in the Naqada region (Cappers et al., 2004; Vermeersch et al., 2004).

Barley is the oldest known cultivated plant in Egypt with grain dating to at least 6000 BC (Hassan, 1988a). Barley cultivated in the Neolithic was of the six-row type (*Hordeum hexastichum*) (Saffiro, 1969). A multi-rowed barley (*Hordeum vulgare)* was present during the Predynastic period (Cappers et al., 2004; Krzyzaniak, 1988; Vermeersch et al., 2004) and was the predominant cereal grain used during the Predynastic in the Naqada region (Hassan, 1981; Netolitzky, 1943; Wetterstrom, 1993) and has also been found along with a 2-rowed variety (*Hordeum distichon*) at Hierakonpolis (Fahmy, 1995, 1999). A cup of barley contains approximately one gram more sugar than a cup of emmer wheat, however, the sugar content of both is still quite low (whfoods.org). Some suggest that barley may have been more important as animal fodder than as a staple grain for human consumption due to the locations where barley tends to be found (Moens and Wetterstrom, 1988; Murray, 1993, 2000a; Wetterstrom, 1982).

Edible Weeds

Some plants that are considered to be weeds have edible parts and may have been cultivated by ancient Egyptians. Garlic has been found in at least one Predynastic working class burial at Hierakonpolis (Friedman, 2003b). It is unclear whether the weeds listed below were actually consumed, as most evidence comes from grain stores or threshing waste (Fahmy, 1997a). Dill (*Anethum graveolens*), dented dock (*Rumex dentatus*), mint (*Labatae sp*), have been found in the Predynastic working class cemetery at Hierakonpolis (Fahmy, 2003a). Onionweed (*Asphodelus tenuifolius*) has been found in Predynastic contexts (Fahmy, 1997a) and has edible roots and leaves. Nettle-leaved goosefoot (*Chenopodium murale*), known from the Predynastic (Fahmy, 1997a), has leaves that, although toxic, may be safely eaten in small quantities. Seeds of this plant may also be ground into a powder to mix with other cereal grains; however the seeds are very small and great quantities would be required. Seeds of the hairy crabgrass (*Digitaria sanguinalis*) may be ground into a flour and are known from the Predynastic (Fahmy, 1997a). The young plants of jungle rice (*Echinochloa colona*), known from the late Predynastic (Fahmy, 1997a), may be eaten. Seeds of the yellow flower pea (*Thermopsis* sp), known from the late Predynastic (Fahmy, 1997a), may be eaten in small quantities when the plant is young. Fully ripe seeds have narcotic qualities. Cress (*Lepidum sativum*) has been found in the Predynastic (Fahmy, 1997a) and has many edible parts. Young leaves may be eaten raw or cooked. The root is often used as a condiment, while seedpods may be used as a pungent seasoning. Oil may also be obtained from the seeds. Green purslane (*Portulaca oleracea*) is known from the Predynastic (Fahmy, 1997a). The leaves and stems may be used as a thickener in soup; ash of the burnt plant is used as a salt substitute. Ripe fruit of black nightshade (*Solanum nigrum*) from the Predynastic (Fahmy, 1997a) can be eaten, however the unripe fruit is toxic. Seeds of the winter tare (*Vicia sativa*) while not very palatable are highly nutritious and are known from Predynastic deposits (Fahmy, 1997a).

Vegetables

Vegetables were most often eaten raw, although they were occasionally boiled or stewed (Morcos and Morcos, 1977). Legumes included beans (*Vicia sp*), lentils (*Lens sp*), cowpeas (*Vigna unguiculata*), and chickpeas (*Cicer sp*) (Cappers et al., 2004; Morcos and Morcos, 1977) and may have provided a significant amount of dietary protein. Peas and bitter vetch were found in Naqada I settlements at Naqada (Hassan, 1981). Seeds and pods of the chickling vetch (*Lathyrus sativus)* are found in Naqada I vases and may have been the main supply of leguminous vegetables during that time (Saffiro, 1969). Egyptians have cultivated okra (*Hibiscus esculentus*) since the Predynastic (Hugot, 1968).

Tubers

Nut sedge is abundant throughout much of the Nile valley. It produces a mass of interconnecting rhizomes that bear small, oblong, bitter-tasting tubers rich in carbohydrates and fiber but low in fat and protein. Club-rush (*Scirpus maritimus, Scirpus tuberosus*) is another sedge tuber rich in carbohydrates. Ethnographic literature gives numerous examples of various species of *Scirpus* being used as food in Egypt (Wetterstrom, 1993).

Fauna in Ancient Egypt

Fish

Fish were abundant in the Nile, the most common being: Nile perch (*Lates niloticus),* bagrid catfish (*Bagrus bayad),* Niger barb (*Barbus bynni),* eel (*Anguilla vulgaris),* elephant-snout fish (*Mormyrus kannume*), Nile tilapia (*Tilapia nilotica*), flathead mullet (*Mugil cephalus*), mudfish (*Clarias anguillaris*), wahrindi (*Scyondontis schall*), African butter cat-fish (*Schilbe mystus*), Nile mocchocus (*Mocchocus nilotica*) and Nile puffer fish (*Tetradon fahaka*) (Morcos and Morcos, 1977; Ruffer, 1919); however, not all of these were exploited. Approximately 17% of the identified fauna from a Predynastic settlement at Hierakonpolis consisted of fish (Van Neer and Linseele, 2004) including catfish, Nile tilapia and most frequently Nile perch (Ikram, 2001; van Neer and Linseele, 2002). There is also considerable evidence for the consumption of fish by the inhabitants of the Naqada region (Netolitzky, 1943) including Nile perch, catfish, tilapia, and barb(Vermeersch et al., 2004). Nile oysters have been found at Hierakonpolis but only in a temple setting, suggesting they may have been ceremonial (Linseele and van Neer, 2004). Evidence for consumption of mollusks by Predynastic populations comes from Lower Egypt (Darby et al., 1977).

Researchers know very little about the cooking of fish in Ancient Egypt. People most likely grilled the fish whole over an open fire soon after catching them. There is evidence for a fish and barley soup in the Naqada region (Netolitzky, 1943). Otherwise, most fish were probably split open, salted and dried in the sun, or placed in large pots for pickling (Morcos and Morcos, 1977).

Reptiles and Birds

A species of turtle (*Trionyx* sp) is present at a Predynastic site in the Naqada region (Vermeersch et al., 2004)and has also been found in temple settings at Hierakonpolis along with a number of crocodiles (Brewer, 1987; Linseele and van Neer, 2004). It is unclear whether turtles would have been part of the diet. Predynastic Egyptians are not known to have eaten any other reptiles.

At least 13 species of birds have been discovered at Hierakonpolis (van Neer and Linseele, 2002). Geese and ducks (Anserinae) are the most common birds found from Predynastic and Dynastic sites (Darby et al., 1977; Morcos and Morcos, 1977). Pigeons, quail and demoiselle cranes were also eaten. Birds were eaten roasted or boiled as well as salted and dried in some parts of Egypt (Darby et al., 1977; Morcos and Morcos, 1977).

Bird eggs were also eaten during the Predynastic. The most common were those of geese and ducks; however, pigeon eggs (*Columba* sp) and others similar to chicken eggs have also been found. Though food lists from the Dynastic period never mention eggs, they were often included in the offerings to gods and the deceased (Morcos and Morcos, 1977).

Wild Game

Early Predynastic populations hunted gazelle, wild goat or ibex (*Capra ibex*), hare (*Lepus* sp.) and oryx (*Oryx* sp.) (Darby et al., 1977; McArdle, 1992; Morcos and Morcos, 1977), all of which are present at Hierakonpolis (van Neer et al., 2004). By the Middle Predynastic, wild game had become less important than domesticated animals. Only two specimens of gazelle, two specimens of hippopotamus (*Hippopotamus amphibious*) and one unidentified artiodactyl were found in domestic contexts at Predynastic Hierakonpolis (McArdle, 1982). In all domestic contexts at Hierakonpolis, wild game constitutes only one percent of the faunal assemblage (Van Neer and Linseele, 2004). Gazelle is the most numerous of the hunted fauna at Hierakonpolis (van Neer and Linseele, 2002).

Domesticated Animals

Domesticated cattle (*Bos ssp*) first appeared in the Sahara during the Neolithic (Banks, 1989; Wendorf et al., 1989; Wendorf et al., 1996). The earliest remains come from the Egyptian Western Desert (Banks, 1989). A large form of cattle *(Bos taurus)* is present at several Predynastic sites (Krzyzaniak, 1988; McArdle, 1992). During most of the Predynastic, cattle were the principal source of animal protein at most sites (McArdle, 1982, 1992). For example, cattle represent 57% of the faunal assemblage at a Predynastic settlement (HK11) at Hierakonpolis (Van Neer and Linseele, 2004). At Naqada however, cattle did not become the dominant species until the end of Naqada I, ultimately replacing sheep/goats (Hassan, 1981). The majority of cattle bones found at Hierakonpolis are adult suggesting cattle may have been used as draft animals or for hides or dairy goods in addition to being a meat source (McArdle, 1992). As far back as records exist, it appears cattle were highly regarded in Egypt (Morcos and Morcos, 1977; Ruffer, 1919).

Pigs (*Sus scrofa*) make up only seven percent of the faunal sample from Hierakonpolis, but were still a significant source of dietary protein and were probably also useful for turning soil and clearing land (McArdle, 1982, 1992). While cattle comprise the majority of faunal assemblage from one settlement at Hierakonpolis, caprines account for the majority of faunal remains from at least two Predynastic localities at Hierakonpolis. An emphasis on sheep and goats in some localities may suggest utilization of milk, either for drinking or cheese (McArdle, 1982, 1992). Differences in horn sheaths suggest that Predynastic people at Hierakonpolis maintained several distinct breeds of goat (McArdle, 1992). Sheep/goat bones were also the most prevalent animal remains in the early levels of settlements in the Naqada region (Hassan, 1981).

Hassan (1981) and Holmes (1989a) suggest that at Naqada, people relied more heavily on animal husbandry than on agriculture for subsistence during Naqada I. Faunal remains found within the settlements and on the location of the settlements in the low dessert suggest a greater reliance on animal husbandry; moreover, the population had only recently settled from nomadic desert groups. The increase in cattle and pig remains beginning in Naqada II, and the movement to settle the floodplain, suggest the beginnings of a heavier reliance on plant and animal agriculture (Hassan, 1981; Holmes, 1989a).

Prepared Food

Bread

Bread first appeared in the archaeological record during the Predynastic period (Saffiro, 1969). The importance of both bread and beer is documented in offering lists, proverbs, scribal exercises and administrative records (Samuel, 2000). While the texture, shape and size of surviving bread varies greatly (Fahmy, 2000; Samuel, 2000), it was typically made of wheat, barley, or millet, but sometimes contained lotus seeds, colocasia rhizome or dum palm dates (Morcos and Morcos, 1977; Ruffer, 1919). While emmer wheat was the predominate grain found in bread at Hierakonpolis (Fahmy, 1997b), barley was most likely of greater importance at Naqada (Netolitzky, 1943).

To clean the grains the Ancient Egyptians would first thresh them, either by beating or sledging, to detach spikelets from the straw. Emmer wheat and barley are hulled, meaning they had to undergo further processing to remove the chaff. This involved trampling and winnowing to remove light weed seeds and light straw. Later, they would sieve the grains to remove larger seeds and unthreshed ears (Murray, 2000a). Workers then removed fine impurities by hand and moistened and lightly roasted the grains before crushing them (Morcos and Morcos, 1977). However, Fahmy (2000) found that emmer wheat bread in Predynastic burials at Hierakonpolis still contained a large amount of chaff.

The specifics of bread making methods are not agreed upon (Samuel, 2000). Generally, crushed grains were ground on a quern and sifted through wide-meshed sieves to obtain flour (Morcos and Morcos, 1977; Samuel, 2000). Workers then kneaded the flour to make bread. Salt or other flavorings such as lotus seeds, colocasia rhizome or dum palm dates were added (Saffiro, 1969; Samuel, 2000). Leavening came into practice in the Late Predynastic (Saffiro, 1969), as yeast was added for fermentation. Bread was initially baked in or over embers and ashes. Later methods include the use of horizontal slabs over ovens and preheated molds (Samuel, 2000).

Examination of ancient bread from tombs shows the inclusion of inorganic matter (mostly quartz) in the loaves. Mineral fragments within the bread may have come from wind-blown sand, soil in which the grain was grown, mud-brick silos used to store the grain, stones used to grind the grain, or the process of baking. Because Naqada is located in a limestone region (Butzer, 1960) and Hierakonpolis in a sandstone region (Hamroush, 1982), the size and hardness of mineral inclusion may have differed. Grinding experiments by Leek (1972) show that a fine flour is only achieved when sand is added to the sample, however Samuel (2000) found the addition of sand unnecessary. Gut contents from the Predynastic working class population at Hierakonpolis show that the bread was very coarse and chaff-filled (Fahmy, 2000).

Milk and Cheese

An inscription in an 18th Dynasty tomb describes how sixty children consumed the milk of three cows, 52 goats and nine she-asses. However, cows' milk was the most frequently consumed (Morcos and Morcos, 1977; Ruffer, 1919). Cheese appears as early as the 1st Dynasty, but it may have been produced slightly earlier. Two containers of cheese were found in a tomb at Sakkara, both with the ancient word for cheese written on them. Milk was also turned into butter for cooking (Morcos and Morcos, 1977). Because the majority of cattle at Hierakonpolis were adult, they were likely used for diary goods (McArdle, 1992). An emphasis on sheep and goats at Hierakonpolis suggests utilization of milk, either for drinking or cheese (McArdle, 1982, 1992).

Oils

Records from the Dynastic period frequently mention oil, which seems to be the second most important article of food after bread. Oil was often used for cooking. Ancient Egyptians pressed the oil from seeds and sometimes fruits, in a bag-press, after mixing the seeds with salt. (Morcos and Morcos, 1977; Ruffer, 1919). Several seeds were used to make edible oils including sesame, lettuce and safflower. Castor seeds (*Rincinus communis*) and balanos nuts (*Balanites aegyptiaca*), which were probably used to make oil, have been found at Predynastic sites (Serpico and White, 2000). The olive tree (*Olea* sp) is first mentioned in the 18th Dynasty and olive oil was in widespread use by the 20th Dynasty (Morcos and Morcos, 1977).

Honey

Bees were present in Egypt in prehistoric times. Man-made beehives, present in the Dynastic or possibly earlier, had a soil and earthenware construction, and illustrations of individuals collecting honey are present in several Dynastic tombs (Morcos and Morcos, 1977). Egyptians used honey as a sweetening agent in pastries and cakes, as well as for medicinal purposes (Leek, 1972; Morcos and Morcos, 1977).

Salt

Salt was traded in the form of large bricks. Naturally occurring rock salt comes from the oasis of Ammon in the Western desert. Natron carbonate or bicarbonate of sodium containing between 4% and 26% salt, occurs naturally in Wadi El-Natron, as well as across the river from Hierakonpolis at El Kab. Egyptians used salt to season food, as a preservative in the salting of fish and poultry, and to make vegetable relishes (Morcos and Morcos, 1977).

Alcoholic Beverages

The earliest identified alcoholic beverage is mead, made from fermented honey and grain. Egyptians have fermented sweet fruits since at least 2000 BC. Date wine was probably the most popular of the fermented fruit juices. To make date wine, workers pressed the liquid from soaked dates and left the juice to ferment by the wild yeasts introduced from the date skins. They sometimes added honey before fermentation. After fermentation, they poured off the liquid and then pressed and filtered the dregs. The alcohol content was probably very high (Morcos and Morcos, 1977).

Wine from grapes was made as early as the 1st Dynasty, although the earliest evidence of grapes comes from the Predynastic (Murray, 2000c). Grape vines (*Vitis vinfera*) have been found at a Predynastic site in the Naqada region (Cappers et al., 2004). Both white and red wines are known, but several types of each probably existed. Wild yeasts from the grape skins converted the sugar into alcohol. Grapes were pressed, fermented, and filtered in a manner similar to used to produce date wine (Morcos and Morcos, 1977).

The earliest recorded reference to beer comes from the 3rd Dynasty. However, there is evidence of beer manufacture in the Predynastic as early as Naqada Ib-IIa (3500-3400BC) (Geller, 1992a:23). Beer was especially important in areas where grape vines did not grow and, therefore, where wine was unavailable. Based on the large numbers of breweries found at Hierakonpolis, beer was an important part of the diet in that region (Geller, 1992a; Takamiya, 2005). Emmer wheat is the predominant grain used in beer manufacture at Hierakonpolis (Fahmy, 1997b). Commoners, as well as higher classes including children, consumed beer (Morcos and Morcos, 1977). However, consumption of alcohol may have been gender specific (Friedman, pers. comm. 2006).

Beer was not used in the way it is today, but simply as a part of the daily diet. The alcohol content was much lower than modern beer, but it was rich in vitamins, protein, starch and calories. Rather than a true liquid, beer was thick and potentially sticky, but was probably also safer to drink than river or pond water (Geller, 1992a; Samuel, 2000).

Beer makers used both barley and emmer wheat to produce white, red and dark brown varieties. Husked grain was probably not used. It has long been believed that grains were made into dough similar to bread with malt and other aromatizing substances such as lupin, skirret, rue, safflower, or mandrake added. Workers then lightly baked the dough into beer-bread, which was then crushed, soaked, salted and mixed in vats. After fermentation, workers kneaded the bread through a sieve and left the liquid to ferment in another vat (Morcos and Morcos, 1977). Recent examinations of the starch residues suggest this was not the case. Morphology of the starch in beer shows that if it were made from loaves of bread, those loaves would have had to be extremely moist and baked at very high temperatures for a long time. This type of baking would have killed any yeast cells or lactic acid bacteria (Samuel, 2000:555). Samuel (2000) suggests instead that milled grain was heated in water to a thick porridge that was used to make the beer.

Archaeological Evidence of Foodstuffs

Direct Evidence

Direct archaeological evidence of which animals were eaten comes from faunal remains within settlements, as well as drawings and sculptures. Direct evidence for use of specific plant foods consists of remains of seed, fruit, root, or tree crops, their pollen, or plant impressions in material such as pottery. There are remains of plant foods in settlements, from gut contents, and found in burials as grave offerings.

Little direct evidence exists for domestication of crops from Egypt (Shaw, 1976). Emmer wheat is the most common grain found in gut contents of the Predynastic working class people at Hierakonpolis. While the bread found in the digestive track of adults is quite coarse, most children had eaten only pure starch grains, (no husks), possibly suggesting use of 'baby food' (Fahmy, 2000:19). Other food remains found in the viscera of Predynastic burials at Hierakonpolis include melon (*Cucumis melo*) seeds, a date-like parenchyma, and unidentified starch grains (Fahmy, 2003b:101).

Fahmy (2003) examined a Predynastic trash mound at Hierakonpolis. Many plants found in the cemetery were also found in the trash mound suggesting those foods were used both as burial offerings and by the living, although this does not necessarily imply consumption. These include barley, flax, wheat, cucumber, jujube, corbichonia, water cress, jungle rice, canary grass, knotweed, rumex, and black nightshade (Fahmy, 2003b).

It should be noted that there is evidence of tetracyclines existed as a result of grain storage methods in Nubia as early as 350-550 AD and possibly earlier. Tetracyclines are a waste product of Streptomycetes, a ubiquitous soil bacteria (Bassett et al., 1980), and have antibiotic properties that may confer a high immunity from infection when consumed (Mills, 1992). Because the soil and climate of Predynastic Egypt was similar to areas known to produce tetracyclines, it is believed that Predynastic Egyptians also received their benefits (Mills, 1992). However, tetracyclines have been shown to cause discoloration of teeth when consumed when the enamel is forming (Holt et al., 2000). No discolored teeth were noted at Hierakonpolis or Naqada.

Indirect Evidence

There are several types of indirect evidence that may be used to identify species consumed and infer diet. Inferences of degree of dependence on agriculture may be made from settlement patterns. For example, increased number, size, and wealth of Naqada I settlements between 3800 and 3600 BC in combination with direct evidence from plant and animal remains, suggest a growth in the importance of agriculture over that in Badarian times (Kaiser, 1957). Archaeologists have found jars from Predynastic Egypt with vegetable material still inside (Hugot, 1968). At Hierakonpolis pottery from

Predynastic burials has been found containing acacia, tamarix, wheat and barley (Fahmy, 2003b). While pottery indicates a tendency to settled life, it does not imply agriculture. For example, prehistoric Alaskan Eskimos were known to produce pottery, but never practiced agriculture (Heizer, 1948; Wilbur, 1956). Jomon hunter-gatherers in Japan used ceramics for storage and cooking (Imamura, 1996). Populations in Siberia, East Asia, and Eastern Europe also made and used pottery before the advent of farming (Jordan and Zvelebil, 2006). In Egypt, archaeologists have found pottery associated with the early Neolithic at Nabta Playa (Wendorf and Schild, 2001).

Biological and climatic data can suggest what potential foods were available. Numerous examples are given above. Artistic representations of food or food production also suggest dietary habits. Clay models of garlic appear in Predynastic cemeteries in Egypt (Shaw, 1976). Tombs from many Dynastic periods depict the collection of honey (Morcos and Morcos, 1977). Several monuments depict bread making (Ruffer, 1919). Wine production is seen on wall paintings as early as 2000 BC. Beer brewing is depicted on Old Kingdom tombs and models of breweries were buried with the dead during the Middle Kingdom (Morcos and Morcos, 1977). Hunting of different game animals and butchering of domesticated animals is depicted on tombs, walls and palettes (Morcos and Morcos, 1977; Ruffer, 1919; Saffiro, 1969). Inscriptions from the early Dynastic suggest that soldiers' diets consisted primarily of bread, beef, wine, cakes and vegetables (Viery, 1891).

Tools used for obtaining or processing food may be used to infer diet. Dynastic Egyptian bas-reliefs show hoes being used as in present times. Hoes are stone objects with a more or less straight blade, used on the end of a digging stick (Hugot, 1968). Ladles and spoons from the Neolithic period suggest the consumption of some type of porridge or leguminous soup (Saffiro, 1969). Sickles first appear for certain in the Predynastic (Hugot, 1968). However, lustrous-edged pieces that may be sickles date to the late Paleolithic. Experiments on reproductions suggest that repeated use in cutting grain or similar flexible substances containing silica produces the gloss or sheen on these pieces (Murray, 2000a). While the sickle may suggest harvest of cereal crops, it may have also been used for uncultivated grasses, typha for huts, or wild fodder (Hugot, 1968).

Dynastic bas-reliefs represent mortars and pestles in use. Their functions include grinding cereal, wild grass-seed, meat, dried fish, unguents, coloring matter, and nuts (Hugot, 1968). Numerous grinding stones date to late Paleolithic sites (ca. 14,500 BP) along the Nile from Sudan to Lower Egypt (Fattovich and Bard, 2004; Vermeersch, 1984; Wendorf et al., 1988) and their large numbers from Predynastic sites suggest use for processing grain or other fibrous foods such as rhizomes and hyphaneae fruits (Wendorf et al., 1988; Wendorf and Schild, 2001).)

Offerings for the deceased provide information on available food products. Emmer wheat, free-threshed wheat and six-rowed barley are present in ceramics from burials at Predynastic Hierakonpolis (Fahmy, 1997b, 2003b) with emmer wheat being the most common (Fahmy, 1998). Food offerings also provide information on differences in availability of food resources between social classes, especially during the Dynastic period. During the New Kingdom, ritual food offerings for upper class deceased include numerous examples of bread in a great variety of shapes, wine-jars, receptacles of fat, oil, flour, meat and fish, roasted and salted birds, as well as prepared dishes. Identifiable vegetable substances from the tombs include peppergrass (*Lepidium sativum*), used as a mustard-type condiment, and cumin (*Cuminum cyminum*) used as a flavoring agent (Mattirolo, 1926). Foods found in the tombs of the workers include as many as fifteen shapes of leavened bread, crushed fig, cooked or smoked meat and fish, a few vegetables (cucumbers and onions), drupes of the dum palm, dates, pomegranates, sycamore and sweet figs, jujubes, carob and acacia pods, and black grapes (Bruyere, 1937).

Biological Evidence of Dietary Deficiencies as Expressed in Hard Tissues

Anemia

Several factors increase the potential for iron-deficiency anemia including dietary deficiency, parasitic involvement and poor hygiene (Martin et al., 1989). Porotic hyperostosis is a physiological response to anemia that results in an increase in the production of red blood cells, causing an expansion of marrow cavities of the bones. The outer layer of the skull becomes very thin and may disappear exposing the diploë (Steinbock, 1976). Cribra orbitalia is a similar condition of the orbit roof (Moodie, 1923).

A high frequency of porotic hyperostosis has been found among Predynastic inhabitants of Naqada (Bartell, 1994; Keita and Boyce, 2001). In a sample of 941 Egyptians and Nubians from Predynastic times to the Christian era, 25% exhibited porotic hyperostosis and cribra orbitalia (Hillson, 1980). However, skeletons in Egyptian sites tend to exhibit higher frequencies of anemias than those in Nubian sites (Hillson,

1980) and sample of Dynastic Egyptians, whose geographical and temporal affiliations are not mentioned, showed cribra orbitalia in frequencies of 7.1 %, (Moodie, 1923). It is suggested that a diet deficient in usable iron, as well as an infestation with parasites such as hookworms and bilharzias, are the underlying causes of anemias along the Nile (Martin et al., 1989).

Bone Growth

Bone growth and maintenance are sensitive to factors such as nutritional adequacy, biochemical stress, disease and age (Martin et al., 1981). The cortical bone of ancient Egyptians did not grow at a normal rate; because of a rapid increase in bone length around age 10, cortical bone thickness actually begins to decrease. Thus, bone growth in length was maintained at the expense of an increase in cortical thickness. Decreased nutrient intake and increased nutrient requirements are responsible for the reduction in cortical bone thickness (Martin et al., 1989). Age estimations based on long bone length for individuals at the Predynastic cemetery at Hierakonpolis are between one and three years younger than age estimations based on dental eruption. An inadequate diet may be one factor contributing to shorter long bones. There have been no comparisons of age based on dental eruption and long bone length for the Naqada populations.

Osteoporosis

Osteoporosis is a form of bone pathology characterized by a decrease in bone mass, which represents a biological response to stress. Age related bone loss can be distinguished from bone loss related to exogenous factors, such as diet and constitution. When osteoporosis is related to age there is less bone, but the bone present is normal. Premature osteoporosis usually involves a decrease in mineralization as well as loss of bone tissue. Mineralization rates are affected by diet and nutrient absorption (Martin et al., 1981).

Females from Meroitic (200 BC – 300 AD), X-Group (350 AD – 550 AD) and Christian Nubia (550 AD – 1400 AD) exhibit early onset osteoporosis, with both loss of bone and a slowing of bone mineralization. Bones of young females are extremely porous due to the increase in resorptive activity. Bone that is present is not well mineralized, suggesting a slower rate of formation than normal (Martin et al., 1989). Females experiencing premature osteoporosis are in their peak reproductive years. The nutritional stresses of pregnancy are most likely the cause, as fetal and newborn nutritional requirements are often taken from the mother's reserves. Lactation alone requires up to 300 mg of calcium and 1000 k cal per day (Martin et al., 1981).

Masticatory Stress

Of all dental pathologies studied, severe attrition (macrowear) may be the single greatest problem affecting the ancient inhabitants of Egypt (Harris and Ponitz, 1980). Some of the oldest Nubian dental remains, dating between 11,950 and 6400 BP, have such heavy masticatory wear that identifiable dental pathology is restricted almost completely to attrition. Seven out of eighteen individuals from Wadi Halfa, show osteo-arthritic lipping of the mandibular condyles. Severe wear and lipping of the condyles also points to heavy masticatory stress (Greene, 1972). The prevalence of severe wear among Egyptians increases through time (Beckett and Lovell, 1994).

The high degree of macrowear in Predynastic and Dynastic Egypt has been partly attributed to mineral fragments found in bread. The principal source of these minerals is sand from the wind-blown desert, the main component of which is quartz (Leek, 1972). Minerals were also introduced into bread through the soil in which the grain was grown, through harvesting (fractured tools), by storing grain in mud-brick silos or wooden granaries, by the process of grinding grain, and by baking (Leek, 1972). There are no differences in dental wear among the classes in Dynastic Egypt (Harris and Ponitz, 1980). Macrowear often becomes so great that enamel and dentin are eroded away until the pulp is exposed, the living tissue inside the tooth dies and the empty root canal becomes a source of chronic infection and abscess (Harris and Ponitz, 1980).

CHAPTER FOUR

SITE INFORMATION

Hierakonpolis

Hierakonpolis is located on the west bank of the Nile in southern Upper Egypt, 100 km south of Luxor (see Figure 2.1). The Greek name Hierakonpolis, meaning "City of the Hawk", is derived from the town's ancient association with the falcon-headed Horus; the patron deity. Nekhen, the ancient name for the site, appears in hieroglyphics in association with Horus as early as the Archaic period, *circa* 3050 BC (Adams, 1977; Wilson, 1955). Today, the site and surrounding area is known locally as Kom el Ahmar, which means the red mound. Kom el Ahmar acquired its name from a large mound covered with fragments of red pottery (de Morgan, 1912; Quibell and Green, 1902). Some older literature refers to the entire site or to the Dynastic town site as Kom el Ahmar (e.g., de Morgan, 1912; Fairservis, 1972; Hoffman, 1972a; Wilson, 1955). Fairservis (1983; 1986) referred to the Dynastic town site as Kom el Gemuwia, after a nearby hamlet. The current Hierakonpolis expedition employs 'Nekhen' to refer to the walled Protodynastic and Dynastic town located in the modern Nile alluvium and designates the general concession region as 'Hierakonpolis' (Friedman pers. comm. 2006).

There are three distinct physiographic zones at Hierakonpolis. These are the alluvium, the relatively flat desert terraces, and desert hills (Hoffman, 1982c). While the Nile generally flows south-north, Hierakonpolis is located at a bend where the water flows west-northwest for a relatively short distance (see Figure 2.1).

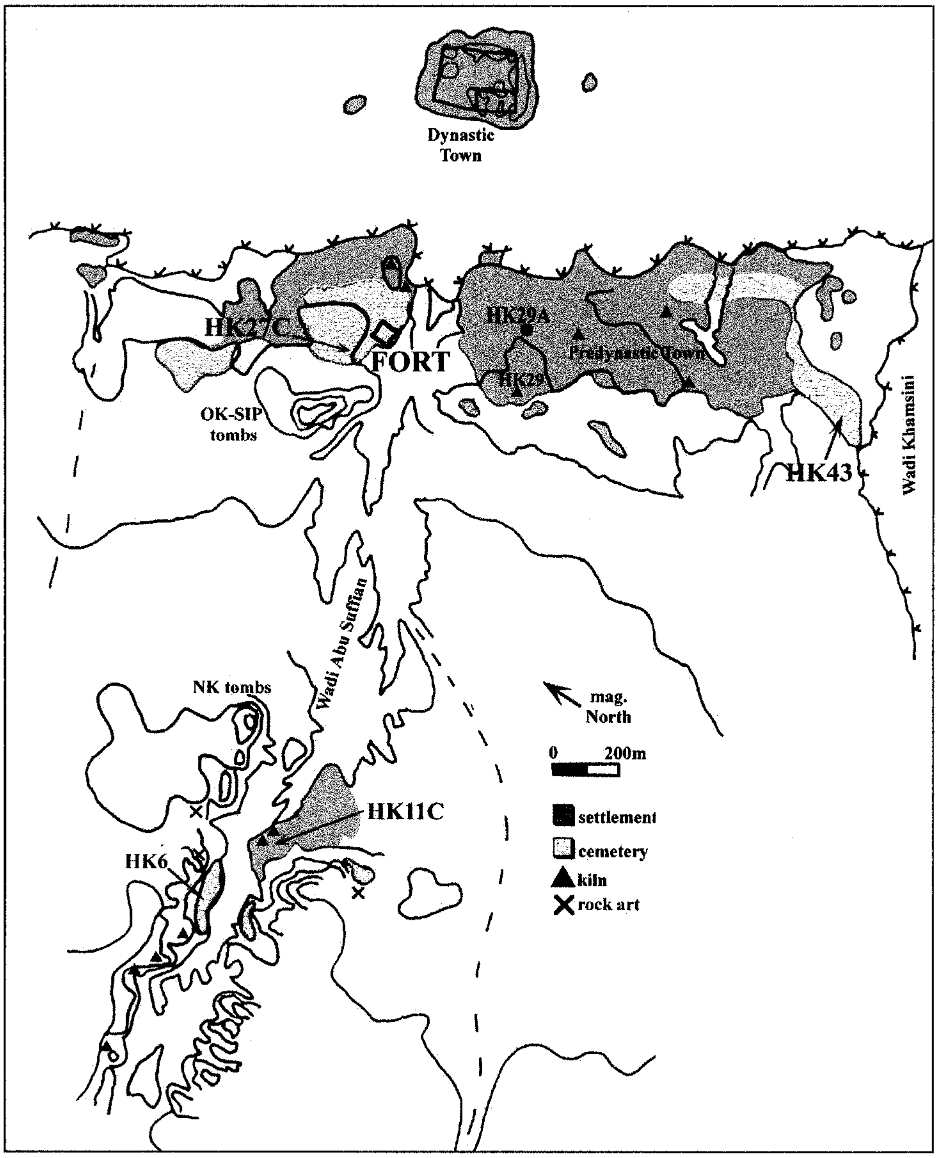

Figure 4.1: Hierakonpolis site map (Friedman, 2004c).

Settlement Patterns

Hoffman and coworkers (1986) suggested that Hierakonpolis was first used as a campsite on a seasonal basis and permanently settled later in Naqada Ia-b (4000-3800/3700 BC). Regional surveys show that Hierakonpolis was a major population center during Naqada I and II (Hikade, 2004; Hoffman, 1982d). Naqada I settlements are predominately situated in the low desert made possible because of occasional Nile flooding that brought water to the area. Settlements show a lateral shift away from the desert, toward and into the alluvium, in early Naqada II (3500-3200 BC). Annual Nile floods in Naqada I probably restricted settlement growth by limiting available space in the cultivation zone (Hoffman et al., 1987; Hoffman and Mills, 1993). Early Naqada II coincides with a marked decline in annual Nile flood height (Hoffman et al., 1987; Hoffman and Mills, 1993), which opened more land for settlement and increased agriculture between Naqada Ic (3800/3700 BC) and Naqada IIa (3500/3400BC). Population size during Naqada II is estimated between 5,000 and 10,000 people (Hoffman et al., 1986).

By Naqada II, large temple and palace-like complexes appear within settlements, surrounded by outliers of varying size and function, reflecting an increase in social, economic and political differentiation (Hoffman, 1982d, 1989a; Hoffman and Mills, 1993). Functional and possibly social differences existed both between and within settlements, including separate habitation, industrial, trash disposal and mortuary zones (Hoffman et al., 1986). Figure 4.1 shows the distribution of these areas.

Core settlement areas at Hierakonpolis were located in the low desert (Hoffman, 1987c) and in Wadi Abu Suffian (Hoffman, 1982d) where the Nile floodplain reaches its maximum width (Harlan, 1985). Harlan (1985) suggests that dwellings within the central area were arranged in a variety of ways. Some were spaced far apart and surrounded by large fenced-in areas, while others shared common walls. A possible third technique was to arrange rectangular houses with their appended courtyards next to one another. Over time there was a tendency for dwellings to become more densely arranged. The urban center was surrounded by outlying settlements that extended northwest and southeast along the valley and low desert for approximately 2.0 km (Harlan, 1985).

Architecture

During Naqada I/II, houses ranged from rectangular to circular; the former are thought to be more permanent based on surviving building materials. A number of irregular shaped structures, possibly outbuildings, are located near the houses. Superstructures typically consisted of mud-plastered reeds supported by wood (tamarix) poles. Walls were secured in linear trenches and the poles in circular holes (Hoffman and Mills, 1993).

The only detailed picture of construction comes from a Naqada I period house that burned; probably due to a spark from a nearby kiln. The roughly rectangular house consisted of a single room, measuring 4.0 m long by 3.5 m wide. It was semi-subterranean, ranging from a depth of 80 cm to 45 cm below surface. The superstructure was similar to that described above; however, light mud-plastered windscreens were attached to the northern and eastern sides. There were eight wood posts supported in mud-packed niches or postholes, three on either end and two near the center. Based on these posts, ceiling height is estimated to be over 1.45 m (Hoffman, 1980, 1982b).

Occupational features within the house include an oven, a storage pot and two upright pottery slabs. The oven had an oval base and mud-brick wall and sat on a 1.5 by 1.25 m platform 30 cm above the floor. A 35 cm deep storage pot, with a diameter of 50 cm, was located at the opposite end of the house. Two upright triangular ceramic slabs situated near the building center may have served as a heat baffle for the oven (Hoffman, 1980).

By Naqada II/III there were massive structures that bear no relationship to earlier houses. Structures in the desert utilized foundations of cobblestones, brick bats and potsherds (Hoffman and Mills, 1993). In the floodplain, mud-brick structures were built over existing surfaces (Friedman, 1996; Hoffman, 1987a; Hoffman and Mills, 1993).

The Naqada II site, HK29A, has been tentatively described as a temple (Friedman, 1996, 2003a; Hoffman, 1982b, 1987a) with an oval mud-plastered floor over 40 m long and 13 m wide. There are actually four distinct, carefully smoothed Nile-mud floors (Friedman, 1996; Hoffman, 1987a). The superimposed floors, separated by sterile layers of fill and other architectural elements indicate at least three phases of construction interspersed with periods of abandonment and reuse (Friedman, 1996, 2003a).

A large paved area seems to have functioned as an open air court (Friedman, 1996; Hoffman, 1987a). The court was initially surrounded by a fence of wooden posts and possibly mud covered reeds that was later replaced by walls of mud-brick (Hoffman, 1987a). A mud-brick wall bound the north perimeter while a composite mud-brick and stone wall bound the southeastern perimeter (Friedman, 1996).

North of the structure, a wall trench over 35 m long supported a wooden post wall that was originally pierced by a gateway near the northwest end (Friedman, 1996; Hoffman, 1987a). Roughly rectangular buildings attached to the walls' outer edge may have served as store rooms or workshops (Hoffman, 1987a). Across from the gateway was a large building, presumably a temple or shrine, approximately 13 m across and subdivided into a number of compartments (Friedman, 1996; Hoffman, 1987a).

Industrial Features

Industrial features at Hierakonpolis include those for the manufacture of ceramics, bread, and beer. Inhabitants of Hierakonpolis may have planned production center locations to keep particularly smoky activities out of settlements (Geller, 1992b), to take advantage of prevailing winds (Hendrickx et al., 2000), for access to floodplain resources, and/or for access to towns and cemeteries (Geller, 1992b).

Perhaps the most famous pottery kiln at Hierakonpolis is the one adjacent to the burned Naqada I house described above. Roughly circular in shape, the kiln measured approximately 6.1m long by 5.0m wide. The most likely configuration is that of a simple kiln surrounded by low, mud walls. Mud walls contained the fuel and funneled the prevailing north wind into a single level of storage pots. There was a series of eight or ten shallow basins with a diameter of about 50-80 cm and a depth of 5-15 cm set in a platform of native silts (Hoffman, 1982b). Other types of kilns must have existed for other pottery (Spencer, 1997). Red ware kiln sites at Hierakonpolis are only identified based on the high proportion of wasters and discarded pottery (Friedman, 1994). Spencer (1997) suggests that the paucity of Predynastic kilns indicates that most were of the open, bonfire type.

Breweries, or vat sites, are similar to pottery kilns, however some differences exist. One brewery at Hierakonpolis has been dated to as early as Naqada Ib-IIa (3500-

3400 BC). It had at least six coarse ceramic vats arranged in two parallel rows (Geller, 1992a). The vessels were conical, measuring approximately 55 cm in diameter and 60 cm in depth (Geller, 1989). The combined volume of the six vessels would be about 390 l (Geller, 1992a). Wood placed around the vat exterior heated the vessels, in contrast to the walled oven configuration of pottery kilns (Geller, 1992a; Takamiya, 2005).

Cemeteries

There are four large Predynastic cemeteries at Hierakonpolis that contain graves dating to Naqada II (see Figure 4.1). These are HK43, comprised of working class individuals, HK27, with middle class individuals and HK6, the elite cemetery. HK33 also contained richer graves and may have also served the elite class, although less is known about this cemetery (Friedman, 1997a). There are also several smaller cemeteries. HK12 and 13 date to the early portion of Naqada I. HK11 is a multi-component site that contains some Naqada I burials (Hoffman, 1982d).

<u>Working Class:HK43</u>

HK43 was excavated by Dr. Renee Friedman between 1996 and 2004 using scientific methods (Friedman pers. comm. 2006). A total of 469 burials dating from Naqada Ic to Naqada IId have been excavated. HK43 is thought to be a working class cemetery based on the general poverty of its burials and the strong muscular nature of the bodies. The cemetery is located on the southeastern edge of the desert concession near the bank of Wadi Khamsini, and continues westward to the border of settlement locality HK54 (Friedman, 1997b, 1999; Friedman and Adams, 2001; Rathbun and Maish, 1997).

HK43 contains conical burial pits lined with a wet mixture of sand and ash in order to maintain the walls in the loose sand (Wrobel, 2001). Unlike the linear arrangements seen in other Predynastic cemeteries, graves at HK43 are arranged in large circles around an empty center. An above-ground monument may once have covered the center. These circular groupings contain individuals of all ages and both sexes. The relationships of individuals within these groupings are unclear. One possibility is that the circles represent family units and may extend over several generations (Friedman, 1999; Wrobel, 2001).

Most burials contain only one individual, although there are a 39 cases of double burial. There is no apparent pattern to double burials as they may contain an adult and child, an adult male and female, two adult females, or two adult males. All bodies are buried in a tightly flexed position, often with hands in front of the face. Most bodies are placed on the left side facing west. However, due to the bend in the Nile there is a difference of 23^{o} between true west and Nile west. Twice as many burials face true west as face Nile west. Burials that face true west have an extremely small margin of error from exact orientation, suggesting a clear knowledge of cardinal directions. While there is no clear pattern to burials facing true west, small children face Nile west more often than adults (Friedman, 1997b, 1999, 2003a).

Mats, sometimes several layers thick, were often placed both below and above the body. Cloth is frequently found and may have served as a shroud covering the entire body. Leather has also been found, especially in the pelvic regions of males (Friedman, 1997b, 1998, 1999, 2003a; Friedman et al., 2004), although some children were covered with a leather blanket (Hendrickx, 2002).

At least three burials show evidence for partial wrapping in linen bandages. The hands and head were padded with bundles of linen up to 10 cm thick and wrapped with narrow strips of linen. Two intact well-preserved burials have linen bundles at the base of the skull, neck, forehead and jaw. In another instance, the greater part of the head was also covered. However at no time were the eyes, nose and mouth covered. To date, all wrapped burials are female (Friedman, 1997b, 1998, 1999; Friedman et al., 2004).

Grave goods are not, however, numerous at HK43. A few burials contained beads. While they are usually few in number (Friedman, 1999), one child was adorned with a bead necklace including carnelian, a white and a green translucent stone, possibly feldspar, and a drop pendant of an opaque green stone (Friedman, 2002). Some graves contained cosmetic palettes (Friedman, 2001). One copper needle, one copper pin (Friedman, 1999) and one copper chisel (Friedman, 2002) have been found in different graves, placed in leather pouches about the hip. Nile aspath shell, ostrich eggshell and flints are occasionally found (Friedman, 2002).

Pottery is the most common grave good. Coarse straw tempered bottles, both large and small, and round-based conical jars make up the majority of the vessels. Red polished bowls and Black-topped jars are less common. In some instances potsherds were found tucked behind the knees. Burials with pottery generally contain only one or two pieces; usually a bottle or bottle and jar set. Bottles may have contained beer, and the jars bread (Friedman, 1997b, 1998, 1999, 2003a; Friedman et al., 2004). Some burials, however, do have more pottery. One woman was buried with two straw-tempered bottles, a conical jar and four bowls. The same woman was also buried with two stone jars, a comb and possibly a palette, although only the rubbing stone was found. This type of wealth was exceedingly rare for HK43 (Friedman, 2002, 2003a).

Middle Class:HK27

The Fort cemetery, HK27, lies partially beneath the Fort of Khasekhmwy that was built generations later, presumably after the cemetery was forgotten (Kemp, 1963). HK27 is located in the desert (see Figure 3.2), north of Wadi Abu Suffian (Garstang, 1907; Lansing, 1935). Hoffman (1987d) suggests that HK27 may have housed retainers, artisans and other dependants of the royal court.

The earliest graves, dating to Naqada IIc, are located primarily to the east side of the Fort and under the entrance. Use of the cemetery spread west, extending well beyond the Fort walls and into the Predynastic settlement area HK27A (Adams, 1987; Lansing, 1935). The cemetery was in use at least until Dynasty I (Adams, 1987; Hoffman, 1982a). Most graves date to Naqada III (Adams, 1987; Kemp, 1963). The predominance of Naqada III graves may be the result of sampling or may reflect an increasing middle class or increasing overall population size relative to previous periods (Adams, 1987).

As at HK43, all bodies are tightly flexed and are usually buried in individual graves. Double burials contained two children or an adult and child, or two adults. One grave contained four children. Most grave pits were oval, with a slight increase in frequency of rectangular graves in Naqada III. The average grave size is less than 1.5 m long. Like HK43, most bodies had the head to the south and were facing west (Adams, 1987). Maps of the graves (Kemp, 1963:plate IV) show what could be a circular burial pattern similar to the HK43 cemetery; however, the circles here are less regular and do not have centers that are completely empty of burials. Further excavations may reveal a clearer pattern.

While said to contain "very few rich graves" (Adams, 1987), the grave goods still outnumber those from HK43 in both quantity and variety. As at HK43, pottery is the most common grave good (Lansing, 1935). Approximately 20% of the graves had more than 10 pottery vessels. One double burial had 38 vessels. The most common types of pottery in Naqada II were the Rough and Decorated wares, which are replaced by Wavy-handled ware, Late ware, and Protodynastic ware in Naqada III (Adams, 1987). Some more elaborate vessels have pictures of birds and trees, and even a few multi-oared boats. Others have simple decorations of spirals or zigzags (Lansing, 1935).

Most graves contained a slate palette, usually a zoomorphic bird or fish shape in earlier graves and a rectangular shape in later graves (Adams, 1987; Lansing, 1935). Exotic items are found in 36% of the graves (Adams, 1987). These include copper bracelets and tools, beads, shells, bone combs and stone vases (Adams, 1987; Lansing, 1935). One of the richest graves contained over 20 pottery vessels, two pebbles, slate palettes, two bone hairpins, a copper bracelet, a bone comb, flints, a copper fish hook, and clay beads (Adams, 1987).

Elite Cemeteries: HK6

HK6 is located on the west side of Wadi Abu Suffian, over 2 km from the desert edge. To the east and west are steep sandstone hills, while at the northeastern end of the wadi are traces of a Naqada I/II settlement (Adams, 1996a, 2004; Hoffman et al., 1982; Hoffman, 1987b). HK6 has been badly plundered in both ancient and modern times; however, useful information may still be gleaned. The cemetery layout, method of tomb construction, and quality of burial offerings suggests the growth of a ruling elite class at Hierakonpolis (Friedman et al., 2002; Hoffman, 1983).

The cemetery was in use from Naqada IC to Naqada IIB and was then used again during Naqada III (Adams, 1995; Figueiredo, 2004). HK6 does not appear to have the circular layout of HK43 and possibly HK27, but instead has a more linear one (Hoffman et al., 1982:Figure I.11). The graves themselves are not small circular pits that are found at HK43 and HK27, but are large tombs. However, not all tombs contained human burials. Several tombs were for the interment of non-human mammals, including dogs, cattle, baboons and two elephants (Adams, 1996a; Hoffman et al., 1982).

Tombs 1, 4, 6, 22, and 22 contained no faunal remains. These tombs are roughly rectangular rooms with mud-brick walls and wood plank lined floors. Postholes and mud plaster indicate that the roofs would have been flush with the ground surface. An additional surface structure probably enclosed the tomb and was itself surrounded by a wooden fence with a gate on the north-east wall (Hoffman et al., 1982). Scraps of linen suggest that the major bones were wrapped in bandages (Adams, 1996a; Hoffman et al., 1982). Tomb 6 contained several straw-tempered rolled-rim jars, of both small conical based and large flattened bases varieties, and Black-topped Red ware of various sizes and shapes (Adams, 1996a; Hoffman et al., 1982).

Tombs 7, 12, 19, and 24 were for animal interments (Adams, 1996a; Friedman, 2004a; Hoffman et al., 1982; van Neer et al., 2004; Warman, 2000). Tombs 2, 3, 5, 9, 11, 13-18, 20, 21, and 23 contained both human and animal remains. In addition to human remains some animals found in the remaining tombs included elephant, sheep, goat, cattle, baboon, and dog (Adams, 1998, 1999b, 2004; Friedman and Adams, 1998, 1999; van Neer et al., 2004) All of these tombs probably contained multiple burials. One tomb (23) contained 16 individuals. (Figueiredo, 2004; Friedman, 2003a, 2005). Tomb 3 was one of the wealthiest graves containing a great deal of Naqada I pottery, a disc-shaped mace head, remains of a bed or bier, matting, basketry, linen and leather rope (Adams, 1996a; Hoffman et al., 1982). Tomb 11 also contained many grave goods, including gold, carnelian, turquoise, lapis lazuli and steatite beads, carved wooden bed legs, ivory and stone inlay, obsidian blades, numerous figurines and a number of broken pottery jars (Hoffman, 1987b:230)..

Elite Cemeteries: HK33

HK33 lies south of Quibell and Green's Predynastic Town, on the desert edge just north of Wadi Khamsini (Quibell and Green, 1902). Many of the 150 graves that Green found were tombs that had been badly plundered. At least five of these were the larger rectangular type similar to those at the royal T cemetery at Naqada (Adams, 1974, 1996a). One of these, Tomb 100 dating to Naqada IId, is the famed 'painted tomb' or 'decorated tomb' (Case and Payne, 1962; Kemp, 1973; Payne, 1973), which dates to the Naqada II period (Adams, 1999a; Case and Payne, 1962).

The main chamber of the painted tomb measured 4.5 m x 2.0 m x 1.5 m (Quibell and Green, 1902) and was divided into two equal parts by a low cross-wall. The walls and floor were lined with mud-brick that varied considerably in size. The roof was probably made of wood (Kemp, 1973; Quibell and Green, 1902). Artifacts from the tomb include two stone vases, four bowls, a lance-head fragment, numerous pots of coarse Brown ware, Red ware and Black-topped Red ware, flints, shells and numerous pottery sherds. The tomb most likely contained many more grave goods prior to looting (Case and Payne, 1962; Payne, 1973).

Three of the walls were plain, whereas the others were decorated. Some were simply plastered in white or had traces of ocher, but one wall contained considerable decoration (Quibell and Green, 1902). This wall contains the largest and most complex Predynastic scene ever found (Adams, 1999a) with several motifs including a conqueror threatening prisoners, a priest, several animals, and boats (Case and Payne, 1962) .

Ceramics

Researchers have divided Predynastic ceramics at Hierakonpolis into several classes based on type of ware/temper. These include straw-tempered ware, untempered Plum Red ware, grit-tempered ware, straw-and-stone-tempered ware and crushed calcium carbonate tempered hard Orange ware. These types of wares may display different rim, base, appendage or body styles (Hoffman and Berger, 1982). The Hierakonpolis region is unique in the use of shale to temper the kitchen wares (Friedman, 2000). There were other regional differences in ceramics between Hierakonpolis and Naqada, mostly during Naqada I. For example, wares at Hierakonpolis were tempered with shale, and the surfaces were wet smoothed or coated with red ochre (Friedman, 1994, 2000).

Lithics

The dominant Predynastic lithic technology was a simple hammer struck flint flake, although blades and bladelets were also produced. Other technologies included the manufacture of bifacial tools and heat-treated flint bladelets. The main classes of lithic tools are burins, retouched pieces, end-scrapers and notches. Other categories include perforators, backed pieces, glossy bladelet tools and bifacial tools (Hikade, 2004; Holmes, 1989a). The chipped stone industry includes edge tools, pointed tools, multi-functional tools, tool blanks and production waste. Although rare, chipped-stone tools were sometimes made from materials other than flint including, quartz, basalt and quartzite (Hoffman, 1972b).

The ground-stone assemblage is categorized as utilitarian or ornamental. Utilitarian examples of ground-stone technology include hammer-stones and grinding stones. Ornamental objects occur in greater quantities and include beads, jars and bowls. Beads were made from carnelian, obsidian, quartz crystal and cryptocrystalline rock. Jars and bowls were made from diorite, porphyry, white marble, alabaster, slate, rhyolite and fossiliferous limestone (Hikade, 2004; Hoffman, 1987e).

Imports

Many of the artifacts from Hierakonpolis were either influenced by or originated in other areas. Footed basalt jars found by Quibell and Green (1902) have a Lower Egyptian origin in Naqada I/II. Quibell and Green (1902) also note many black fancy types of pottery that were influenced by Lower Egyptian types (Adams, 1996b).

Imports from Naqada II suggest contacts both to the north and south. Fourteen pottery sherds have a whitish fabric with gray inclusions typical of southern Palestine in that time period (Adams and Friedman, 1992). Many of the imported vessels were discarded, suggesting that they were valued for their contents more than anything else (Friedman, 1996).

The supply of exotic items increases during Naqada III. Elite tombs contained gold, granite, turquoise, lapis lazuli, silver, and obsidian blades. Both gold and garnet occur in the Eastern Desert, where lapis lazuli is assumed to be from Afghanistan. Silver likely came from western Asia (Adams, 1996b). The obsidian compares well to that from the African Rift volcanic system, including Ethiopian and South Arabian sources (Bavay et al., 2000).

Naqada

Naqada is located on the west bank of the Nile in Upper Egypt, approximately 28 km northwest of Luxor (see Figure 2.1). The Naqada region consists of an area of low desert that extends approximately 22 km from Ballas in the north to Danfiz in the south (Friedman, 1994). The site consists of a series of settlements and cemeteries located along the desert edge (Petrie and Quibell, 1896). Directly across the Nile lies the mouth of Wadi Hammamat, which is one of only a few direct accesses to the Red Sea coast and Eastern Desert. In the middle Predynastic, Naqada developed into a large urban center that controlled access to much of the gold and other mineral wealth of the Eastern Desert (Bard, 1987a; Trigger et al., 1983). Naqada was also a center for craft specialization. Craft production, control of minerals and distribution of these goods would require a ruling elite within a structured society (Bard, 1987a). Eventually, the Predynastic settlements of Naqada developed into the city of 'Nubt', presumably translated as 'city of gold' (Bard, 1987a; Trigger et al., 1983). In combination evidence for the control of gold resources, its geographic location, estimated population, and segregation of wealthy cemeteries suggest that Naqada was the capital of a chiefdom or city state during the Predynastic period (Kemp, 1989:35).

In the late 1800s de Morgan excavated two large tombs dating to Naqada III, a lower status cemetery and some kitchen-middens (de Morgan, 1897; Hassan, 1999; Holmes, 1989b). In 1894, Sir Flinders Petrie and J.E. Quibell excavated three Predynastic cemeteries and two settlements: North Town and South Town. In addition to the Predynastic components, Petrie and Quibell also excavated a number of Dynastic tombs, a temple and a small step pyramid (Petrie and Quibell, 1896). Petrie based his Predynastic chronology on the ceramics from Naqada (Hendrickx, 1996). Modifications of this are still used today (Hendrickx, 1996).

Reisner and coworkers excavated cemeteries in the Naqada region in 1899-1900 (Mortensen, 1991). Garstang conducted some excavations at Naqada in 1904 but left few written records of his findings (Friedman, 1994; Garstang, 1905). Lortet and Gaillard (1909) visited the site a decade after Petrie and made notes on the Predynastic settlements and cemeteries. An American expedition directed by Fekri Hassan and T.R. Hays and an Italian group from the Oriental Institute of Naples conducted excavations at the settlement locations of Khattara and South Town in the 1970s and early 1980s (Barocas et al., 1989; Hassan, 1981).

Settlement Patterns

Archaeologists have found several settlement areas at Naqada, ranging in size from a few thousand square meters to 30,000 m^2 (see Figure 4.2). In addition to North Town and South Town, the largest of the settlements, there were also settlements labeled Khattara (KH) one through seven (Hassan, 1981, 1999). All are arranged in a linear fashion at intervals of approximately 2.0 km, along the desert edge near the floodplain. Most date to the Predynastic period, although KH2 dates to Dynasty I and there are no dates for KH5. Ceramics suggest that KH1, KH3, KH4, KH6 and KH7 were occupied during Naqada I with a shift to North Town and South Town in Naqada II (Hassan, 1981). Of all Predynastic settlements, only South Town shows evidence of architectural elements. The other sites contain residues of domestic habitations; hearths, whole ceramic vessels, dung mats and wood posts (Hassan, 1984).

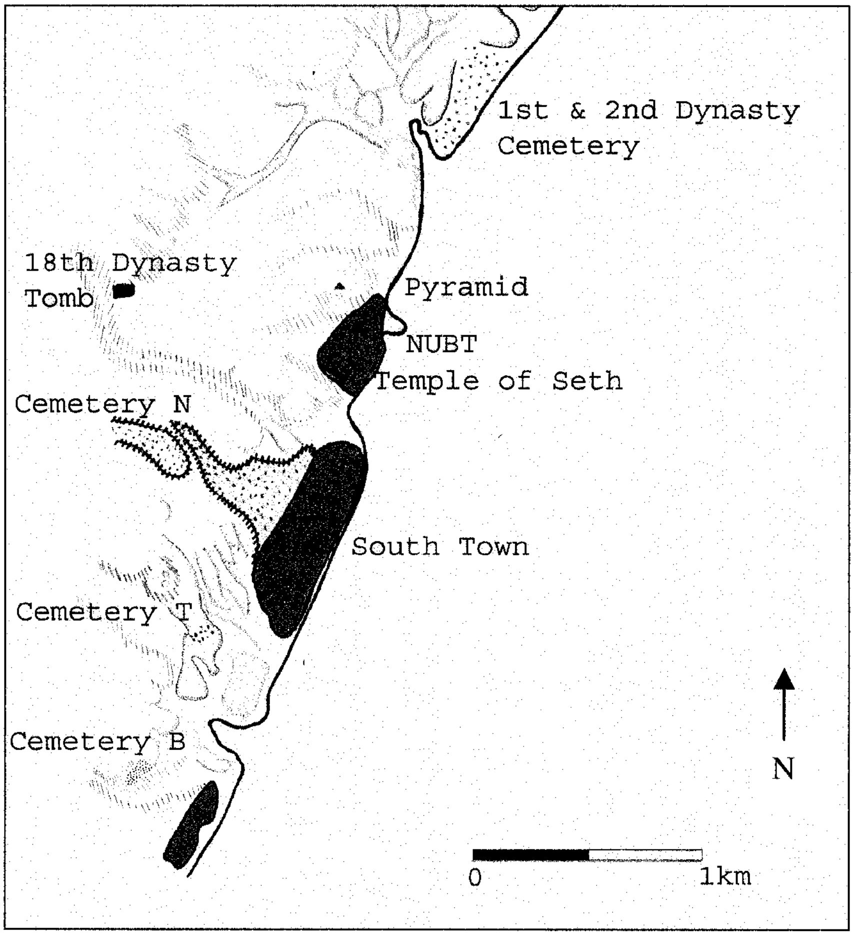

Figure 4.2: Naqada site map. Adapted from the Petrie Museum.

Khattara

The Khattara settlements vary in size and complexity but are believed to have been a single group of associated communities (Friedman, 1994). Populations at the settlements are estimated to range from 50 to 250 people (Hassan, 1981:64; 1988b:154-5). Despite a lack of well-preserved architectural remains, the earlier settlements, particularly KH3, display evidence of habitation areas and associated animal pens. Earlier settlements tend to be smaller and show indications of many overlapping huts, suggesting seasonal use. At least some earlier huts were made of wickerwork around a frame of wood posts (Holmes, 1989b), whereas later sites, such as North Town and South Town, contain dwellings made from mud and rubble (Hassan, 1999).

Other features within the Khattara settlements consist of small mud-lined storage pits, post-holes and hearths. Trash areas were interspersed with domestic dwellings (Drake, 1980; Holmes, 1989b), and post-holes and compact zones of accumulated sheep dung suggest animals were kept within habitation areas (Hassan, 1979). Graves were found within the habitation area at KH3, and although looted, contained jewelry and pottery (Drake, 1980).

North Town

North Town is also known as Nubt after Set Nubti's temple on the spur of the desert (Petrie and Quibell, 1896). North Town is not on Petrie's map of sites at Naqada because the layer of occupation was extremely thin, ranging from 1.27 cm to 60.96 cm (Petrie and Quibell, 1896). However, North Town, covering approximately 40,000 m^2, is as extensive as South Town (as cited in Bard, 1987a). During Naqada II, the town expanded both southwards and northwards away from its center (Midant-Reynes, 2000b). No architectural elements were found, but there was a large system of trenches at right angles to one another, the largest measuring 3.6 m long by 7.6 cm wide. These trenches may have supported walls of a large structure. A few children were found buried within the town. These were flexed burials containing a few Dynastic pots (Petrie and Quibell, 1896).

South Town

Based on ceramic evidence, South Town was occupied during the Predynastic, Early Dynastic and Late Dynastic (Barocas et al., 1989). Combined radiocarbon dates and ceramic indicators provide an average date of 3580-3300 BC (Hassan, 1984; Hassan and Matson, 1989). South Town is located within the central part of the Naqada area, but gradually moved from the desert toward the river during Naqada II (Midant-Reynes, 2000b). South Town is believed to have been an administrative center in Naqada II and to have contained the densest population from then and into the Dynastic period (Friedman, 1994).

Features found within the town include postholes, notches and grooves cut into sediments and piles of mud bricks from collapsed walls. There is also a rounded ditch north of the town (Barocas et al., 1989). South Town did contain some evidence of architectural structures, the largest of which is a rectangular mud-brick structure measuring 50 m x 30 m and which is suggested to be the remains of a temple or royal residence. Just south of the temple/royal residence is a group of rectangular houses and a 2.0 m thick enclosure wall (Midant-Reynes, 2000a). The temple/royal residence may be similar to the temple seen at Hierakonpolis (Friedman, 1994).

Cemeteries

There are at least four cemeteries at Naqada, with over 2200 graves. All cemeteries are located along the desert edge, mainly in the gravel shoals of wadis (Bard, 1987b) (see Figure 4.2). Like Hierakonpolis, geographical separation of the cemeteries provides an opportunity to examine individuals of different social classes. The cemeteries are designated 'B', after a nearby mound called Kom Belal, 'T', which is located near two tumuli and the 'Great Cemetery' or 'N', which is the largest.

Cemetery N

The Great Cemetery was originally called the 'Great New Race' cemetery because Petrie initially believed the burials represented a different population from that of pharaonic Egypt (Petrie and Quibell, 1896). These represented the first Predynastic burials ever encountered in Egypt and while their true affiliation was soon realized by Petrie it was reported only as a news brief (Fowler et al., 1898).

Petrie's map (1896) shows 2043 graves, of which he excavated 1953. Bard (1994) suggests the burial area can be separated into two geographically distinct portions: a western cemetery (N West) and an eastern cemetery (N East) with a wadi running between the two. While it appears that the cemetery grew from two smaller groups of earlier graves, it is unclear whether this separation was intentional or incidental (Payne, 1992). Maps produced by Payne (1992) do not show any clear trends in the location of burials through time.

Burials in Cemetery N East and most of N West are believed to be those of the working class, similar to HK43 at Hierakonpolis. The skeletal remains appear to be those of strong, hard-working individuals (Warren, 1897). Warren (1897) described the limb bones as displaying a 'vigorous musculature.' The graves also tend to be rather poor, with few grave goods (Bard, 1994b).

A few graves from the western part of N West are similar to cemetery T, with large graves and many grave goods. The remainder of the burials in N West and N East have smaller graves containing only one or two pots (Bard, 1994b). Bard (1994b) suggests that despite the relative wealth of some graves in N West, the individuals did not hold as high a social status as those who were geographically isolated in Cemetery T because they were buried near the poorer graves.

The majority of the bodies in Cemetery N were buried on their left sides in a flexed position, with their heads to the south and facing west (Bard, 1987a; Petrie and Quibell, 1896). Unlike those at Hierakonpolis, most of the graves in both the N West and N East cemeteries are rectangular, with only a few oval as seen in the working class cemetery at Hierakonpolis (Bard, 1987a). Graves of N West are arranged in rows (Bard, 1994b).

The earliest use of Cemetery N was near the occupation at South Town. Through time the cemetery was extended west as the town expanded north and east (Bard, 1987a; 1989). Both N East and N West contain more burials dating to Naqada II than to earlier or later periods, while N East contains more burials from Naqada I than N West, and N West contains more burials from Naqada III than N East (Bard, 1994b).

Cemetery T

Cemetery T is located 389 m south of the Great Cemetery. Burials in Cemetery T date to Naqada II and III (Bard, 1994b). Cemetery T is thought to be an elite cemetery because it is small (69 burials) and contains large, rich graves (Case and Payne, 1962;

Johnson and Lovell, 1994; Kemp, 1973; Petrie and Quibell, 1896). For example burial T5 had 60 grave goods including many made from rare materials, such as diorite, gold, coral, marble, silver, and turquoise (Bard, 1994b). With only one exception, burials were rectangular in shape (Bard, 1987a). The cemetery also contained one burial with over 20 dogs (Petrie and Quibell, 1896).

The low number of burials and the isolated location of Cemetery T suggests that it is the burial place of figures of authority and their kin, who held an elite status not afforded to those in Cemetery N West (Bard, 1994a). Johnson and Lovell (1994) found the individuals in Cemetery T to be biologically distinct from those in Cemetery B and Cemetery N on the basis of dental morphology. Biological differences between individuals in Cemetery T and those in other cemeteries was confirmed by study of cranial morphology (Prowse, 1994). The difference is probably due to inbreeding, supporting the inference that this is a ruling class cemetery (Lovell and Johnson, 1996).

Cemetery B

Cemetery B is located approximately 611 m south of Cemetery T, on a knoll west of the floodplain; it is not near any known settlements (Bard, 1987a). There are 144 known graves most of which date to Naqada II, with very few graves from Naqada I or III (Bard, 1987a; 1989). Burials in Cemetery B are similar to the poorer graves in Cemetery N. Bodies are in a flexed position, lying in pits. Most grave pits are rectangular while only a small percentage are oval or round (Bard, 1987a). The head is generally pointed to the south and facing west. Bodies were sometimes covered with matting or animal skins. Only six graves contain more than one individual (Bard, 1987a). The most common grave goods are pots, sometimes accompanied by slate palettes and beads (Bard, 1994b). Davis (1983b) suggests that the small size and isolated nature of Cemetery B means the individuals buried there were likely of a higher social status than those in the Cemetery N. A study of dental variation shows that people buried in individuals in Cemetery B may be biologically intermediate between the two segments of the populations in the other cemeteries (Lovell and Johnson, 1996). It is possible that Cemetery B is similar in status to HK27 at Hierakonpolis. This is supported by changes through time; the burials of Cemetery B and the wealthier graves of N West increase in size, while those in the remainder of Cemetery N decrease in size (Bard, 1987a).

Ceramics

Predynastic ceramics from Naqada settlements are almost exclusively sherds (Hassan and Matson, 1989). Most are Polished Red and Rough ware. The polished red sherds are probably from Black-topped Red vessels; several complete Black-topped Red vessels have been discovered at KH3. Excavations also produced a few sherds of Rippled Black ware, White Cross-lined and Orange pottery from the other Naqada I settlements. Most ceramics from North and South Town are Rough ware with some Decorated and Wavy-handled pottery (Hassan and Matson, 1989; Holmes, 1989b). The local ceramic tradition at Naqada differed from that of Hierakonpolis, especially during Naqada I. At Naqada, wares were tempered with ground potsherds or grog, and surfaces treatments included self-slip and brown, red or gray-black washes (Friedman, 1994, 2000). The untempered wares have a slightly different base morphology than those at Hierakonpolis (Friedman, 1994).

Lithics

Nearly all of the stone tools at Naqada are made from nodules of high quality, predominately beige, flint from local wadis. Heat treatment is rare; only a few elongate flakes and secondary blades from KH3 and South Town exhibit evidence of heat treatment. A small number of tools, for example a plane and an axe from South Town, are made from silicified limestone. Hammerstones are roughly spherical and made of igneous Kokhan Volcanic rock (Holmes, 1989b).

The most common stone tools in the earlier settlements at Naqada are burins, scrapers, denticulates, truncations and perforators. Burins are most abundant, making up 31.2% of the lithic tool assemblage (Holmes, 1989b). Planes, bifacial tools, concave-based projectile points and axes are also present, but in fewer numbers. The axes are very distinct to Naqada (Hassan, 1999; Holmes, 1989b).

Lithic assemblages at North Town and South Town are similar to those from earlier settlements except for the appearance of sickle blades (Hassan, 1999; Holmes, 1989b). Despite the emergence of blades in Naqada II at North Town and South Town, only a few blade cores have been found at these sites. Similarities between the lithics at Naqada I and Naqada II sites suggests a single, consistent lithic industry (Holmes, 1989b).

Lithics from Petrie's cemetery excavations, predominately Cemetery N, include 158 pieces of debitage, 103 tools, one core and 43 Paleolithic artifacts. Most of the debitage pieces are secondary blades and bladelets. One secondary blade, from a late Predynastic grave, and one tool are obsidian, the source of which is uncertain. The remainder of the cemetery lithics are local beige flint. Some of the Paleolithic artifacts appear to be freshly re-touched, suggesting reuse in the Predynastic. However, most Paleolithic artifacts probably fell into the graves accidentally during initial digging (Holmes, 1989b).

Imports

Many artifacts that were likely imported were found in the graves at Naqada. These include items of lapis, turquoise, silver, obsidian, N-incised ware, knobbed bowls, spouted jugs, Wavy-handled jars, loop-handled jars, a lug-handled pot, a Kernos ring and cylinder seals. Imported materials are not restricted to one cemetery. In fact, only a few examples of the imported items are found within the elite Cemetery T (Griswold, 1992).

Regional Variation between Hierakonpolis and Naqada

Hierakonpolis and Naqada were the largest urban centers in Upper Egypt during the Predynastic period, although one other large center, Abydos, emerged towards the end of the Predynastic. The surrounding farmsteads would have depended on either Hierakonpolis or Naqada for the exchange of specialized crafts. Likewise, each craft worker would have been dependent upon as many as 50 agricultural producers (Midant-Reynes, 2000b).

The way in which these two large urban centers dealt with each other is not clear. There is evidence for a certain degree of regional variation between Hierakonpolis and Naqada. The results of this study (see Chapters 8 and 9) suggest some degree of dietary difference between the working class populations of the two sites during the Predynastic period. Combined with archaeological data and biological affinity studies, this dissertation contributes the current discussions of cultural similarity and differences at the sites, and among the working class in particular.

Regional variation is evidence in the burials of the working class inhabitants of Hierakonpolis and Naqada. Burials at HK43 at Hierakonpolis were round or oval in shape and arranged in a circular pattern around a large empty space that may once have contained a superstructure (Friedman, 1999, 2003a; Wrobel, 2001). Cemetery N at Naqada contains mostly rectangular graves arranged in a linear pattern (Bard, 1987a, 1994b).

Burial style is not the only variation; there are also differences in technologies. For example, while many of the ceramic techniques and styles were similar, Hierakonpolis pottery was unique in the use of shale as a tempering agent. In the place of shale temper, ceramic produces at Naqada used broken pieces of pottery or grog (Friedman, 1994, 2000). Likewise, while pottery at Naqada was finished with a slip or wash, that at Hierakonpolis tended to be wet-smoothed or covered with red ochre. The base morphology of untempered wares also differed slightly between the sites (Friedman, 1994, 2000). While the flake and blade technologies at Hierakonpolis and Naqada appear to represent a continuum of forms, axes at Naqada are distinctive to that region and microdrills occur only in the Hierakonpolis regions (Holmes, 1989a).

As supported by the findings of this study, archaeological evidence suggests that there should be some dietary differences evident on the teeth of the inhabitants from the two sites. Hierakonpolis is located in a sandstone region (Hamroush, 1982), where Naqada is in a limestone region (Butzer, 1960), which could impact the amount, size, and hardness of grit in the diet . Emmer wheat was the predominant cereal crop grown and utilized at Hierakonpolis (Fahmy, 1995, 1997b, 1999), while the inhabitants of Naqada relied more heavily on barley (Hassan, 1981; Netolitzky, 1943; Wetterstrom, 1993). Evidence of beer manufacture has been noted at Hierakonpolis but not at Naqada (Fahmy, 1997b; Geller, 1992b, a; Takamiya, 2005). However, Naqada was excavated several decades before the breweries were discovered at Hierakonpolis. Grape vines dating to the Predynastic have been discovered in the Naqada regions, but not the Hierakonpolis region (Cappers et al., 2004; Murray, 2000b). It has been suggested that beer would have been more important in regions where grapes, and therefore wine, were not available (Geller, 1992a).

CHAPTER FIVE

DENTAL PATHOLOGIES

The study of teeth appeals to researchers for several reasons. The hard and tough materials of which teeth are made (enamel and dentin) often preserve better than other parts of the skeleton. Teeth are readily identifiable outside of their bony sockets (Hillson, 1979) and unlike bone, enamel is unable to remodel or be resorbed once formed. Thus, any defect of the tooth becomes a permanent indicator of stress that occurs during development (Goodman et al., 1984b; Pindborg, 1970; Sarnat and Schour, 1941). Because teeth come into contact with all consumed food, researchers often use dental pathologies to reconstruct ancient diets. Dietary factors affect teeth even during their formation (Hillson, 1979). Dental pathology is the study of conditions that affect teeth and their supporting structures.

Pathological lesions may reveal a specific disease or activity or they may be a nonspecific indicator of stress. Carious lesions and calculus provide direct evidence of diet, as the frequency of both increase relative to the amount of carbohydrates ingested (e.g., Bang and Kristoffersen, 1972; Christophersen and Pederson, 1939; Cran, 1959; Larsen et al., 1991; Mayhall, 1970; Pederson, 1938; Turner, 1979). While dental calculus is not pathological, it is often included in studies of dental pathology as an indicator of diet (Chamberlain and Witkin, 2003; Davis and Janssen, 1991; Harris and Ponitz, 1980; Ibrahim, 1987; Littleton and Frohlich, 1993; Lukacs, 1992; Pechenkina et al., 2002; Strouhal, 1984). Dental abscess is also a dietary indicator. If carious lesions or dental macrowear become severe enough to expose the pulp cavity an abscess may form

(Buikstra and Ubelaker, 1994). Periodontal disease may also reflect diet, although slightly less directly than caries (Hillson, 1996). Linear enamel hypoplasias give an indication of overall childhood health (Buikstra and Ubelaker, 1994; Goodman et al., 1980; Goodman et al., 1984b; Goodman and Rose, 1990).

Carious Lesions

Caries is among the most frequently reported pathological conditions of the dentition. Carious lesions are areas of the teeth that acids produced in dental plaque by bacterial fermentation have destroyed (see Figure 5.1) (Heloe and Haugejorden, 1981). The relationship between diet and carious lesions is well established (e.g., Bang and Kristoffersen, 1972; Larsen et al., 1991; Mayhall, 1970; Pederson, 1938; Turner, 1979). Turner (1979:631) suggests that the assessment of the role of agriculture in diet through oral health should be made solely with caries, because carious lesions have the "most direct and strongest relationship with amount, kind, texture, and adhesiveness of all possible foodstuffs." Thus, the frequency of carious lesions within a population gives an important clue as to dependency on cariogenic cultigens and overall subsistence practices.

Etiology

Carious lesions are initially identifiable as a slowly progressing brown or rapidly progressing white spot. Both brown and white spots consist of a demineralized subsurface covered by what appears, even with weak magnification, as an intact enamel layer (Frank and Brendel, 1966). However, the surface enamel is not actually intact. The prism sheaths are broader than normal, which allows access to the subsurface enamel. Prism cores are then destroyed, followed by the destruction of the inter-prismatic material (Haikel et al., 1983).

Figure 5.1: Carious lesion. Arrow points to carious lesion on a maxilla from Hierakonpolis. Width of photograph is approximately 6 cm.

Miller (1890) first recognized bacteria as the causative agent of carious lesions. *Streptococci*, especially *S. mutans*, and other gram-positive filamentous bacteria are most often associated with cavitated carious lesions (Gibbons and van Houte, 1975). However, coccoidal and other rod-like organisms dominate early formation of the lesion, with filamentous bacteria appearing later (Frank and Brendel, 1966).

Carious lesions develop under bacterial masses called dental plaques (Gibbons and van Houte, 1975). There are two categories of dental plaque. One type undergoes calcification, forming dental calculus with no apparent deleterious effect to the enamel surface. The second type is associated with incipient dental caries (Frank and Brendel, 1966) and is made up of carbohydrates adhering to the enamel surface. Carbohydrates feed the bacteria, which produce lactic acid as a waste product. Lactic acid dissolves the enamel, thereby producing the carious lesion. More bacteria create a more acidic environment. If the majority of the food consumed consists of proteins, providing little food for bacteria, the environment of the mouth is alkaline and fewer lesions will develop (Hillson, 1979). While carbohydrates are the main food source for bacteria, they are not all equally beneficial to the bacteria. Sucrose is most conducive of carious lesion formation (Hillson, 1979). Starch is slightly less so because it must be hydrolyzed before the bacteria can ferment it and because starch does not easily diffuse into bacterial masses (Gibbons and van Houte, 1975).

Diet is not the only factor that influences the production of carious lesions. Saliva acts as a buffering agent, minimizing the effects of acids produced by bacterial fermentation. Antibodies against oral bacteria may also exist in saliva (Darling, 1959). Most importantly, however, the flow of saliva helps to remove food debris. If the salivary glands are functionless, caries eventually destroy all teeth in the arcade (Applebaum, 1932). Fluoride, which occurs naturally in various concentrations in many geographic areas, also decreases the formation of carious lesions (Rugg-Gunn et al., 1973).

The location of carious lesions along the tooth row differs among populations depending upon subsistence practices. Lesions tend to occur almost exclusively at the cemento-enamel junction in pre-agricultural populations, as meats commonly become lodged around the gum-line. Populations that regularly consume refined carbohydrates more often develop carious lesions on the crowns, as carbohydrates are sticky and are easily trapped in grooves of the enamel surface (Smith, 1986b).

In many locations, carious lesions differ in frequency between males and females (Lukacs, 1996). However, the variation is a reflection of differences in foods consumed rather than susceptibility. Some populations show no correlation with age, while others may show an increase or a decrease in carious lesion frequency as individuals age (Corbett and Moore, 1976; Costa, 1980; Moore and Corbett, 1971). Increases most likely result from a greater amount of time for lesions to form, while decreases may relate to tooth wear. As a tooth wears, there are fewer grooves in which sticky foods may become lodged, thereby reducing the risk of bacterial decay (Cran, 1959).

Caries in Egypt

Although generally low, the incidence of carious lesions increases through time in Egypt. Several studies conclude that the frequency of carious lesions is low for the Predynastic (Ibrahim, 1987; Leek, 1966; Podzorski, 1990). Leek (1966) examined skulls from several collections including pre- and early Dynastic samples from Hierakonpolis, the 1st and 2nd Dynasty from Tarkhan, the 4th through 18th Dynasty from Qaw, the 9th Dynasty from Sidmant and the 11th Dynasty from Qurna. The frequency of carious teeth is less than two percent in all populations, although no attempt to correct for ante-mortem tooth loss was made. In that study, the skulls from Hierakonpolis must have belonged to the middle class cemetery (HK27), as the working class cemetery (HK 43) had yet to be discovered at the time of the 1966 study. Ibrahim (1987) found that caries affected 2.2% of teeth and 12.8% of individuals in a combined sample from Predynastic Badari, Abydos, El-Amra and Naqada.

Some researchers have reported an increase in caries frequency in the Dynastic period (Ibrahim, 1987; Thornton, 1990), while others have reported the opposite (Greene et al., 1967; Grilletto, 1973; Leek, 1966). The discrepancy reflects samples studied; studies that combine individuals from all of the dynasties find an increase in caries frequency from the Predynastic to the Dynastic. Ibrahim (1987) found an increase from 2.2% to 3.7% of teeth affected and an increase from 12.8% to 23.3% of individuals affected.

Researchers who examine smaller samples from the Dynastic period find lower frequencies in the early Dynastic than have been reported for the Predynastic. These studies also suggest higher frequencies in later Dynastic periods than the early Dynastic or Predynastic. When the early and late Dynastic samples are combined, Dynastic populations appears to have higher frequencies of carious lesions than Predynastic Populations. Leek (1966) found that 1.2% of teeth in the 1^{st} and 2^{nd} Dynasty were carious, while only 0.4% in the 9^{th} Dynasty and 0.8% in the 11^{th} Dynasty were carious. The frequency increases dramatically in the 21^{st} to 22^{nd} Dynasties when 6.9% of the teeth are carious (Smith, 1986c). By the 25^{th} to the 30^{th} Dynasties carious lesion frequency is 16.78% (Turner and Bennet, 1913). More recent populations have an even greater frequency of caries than the Dynastic (Davis and Janssen, 1991; Hillson, 1978; Ibrahim, 1987; Thornton, 1990).

Egyptian females from the Predynastic and Dynastic periods tend to have a greater number of carious lesions than males (Beck and Greene, 1989; Hillson, 1978; Strouhal, 1984; Thornton, 1990). In Predynastic populations carious lesions most frequently occur on the occlusal surface, followed by the inter-proximal neck area. In both the Dynastic and later populations, the inter-proximal neck area is the most prevalent location for carious lesions, followed by those of unknown origin (Ibrahim, 1987). Lesions of unknown origin are those that are too large to distinguish where the lesion started. Differences in lesion location suggest a change in diet from the Predynastic to the Dynastic.

Calculus

Calculus is a highly mineralized plaque deposit adhering to the enamel surface (see Figure 5.2). Calculus is 79-80% inorganic, consisting mainly of crystalline salts. The organic portion is made up of small amounts of proteins, carbohydrates and lipids (Scheie, 1989). While calculus itself is dead, a layer of active plaque usually covers it. Plaque is comprised of living bacteria in an extra-cellular matrix. As the active layers of plaque mineralize, new calculus is formed. The mechanism of plaque mineralization is not well understood (Hillson, 1986).

Figure 5.2: Calculus. Arrow points to calculus covering the lingual side of a mandibular central incisor from Hierakonpolis. Width of photograph is approximately 3 cm.

Etiology

The most common bacteria found in dental plaques are *Streptococci* and *Actinomycetes,* although *Veillonella, Neisseria, Fusobacterum* and some bacteriodes also occur (Hillson, 1986). Proteins from saliva form an acquired pellicle that normally coats all surfaces of the mouth and protects the teeth from oral bacteria. However, within two hours of careful cleaning, microorganisms, mostly *Streptococci,* become absorbed into the pellicle. Filamentous bacteria appear after approximately one week and dominate the plaque structure after two weeks (Marsh, 1980).

Oral bacteria adhering to the tooth are embedded in a matrix, made up partly of proteins in the saliva and partly manufactured by the bacteria themselves. The conglomeration of matrix and bacteria is referred to as a dental plaque (Dent and Marsh, 1981). The amount and type of extra-cellular matrix in the plaque may vary. The bacteria may be widely separated by the matrix, or packed tightly together (Frank and Brendel, 1966). The matrix is held together by polymers, such as the polysaccharide adhesives produced by *Streptococci* (Dent and Marsh, 1981).

Food debris rarely becomes incorporated into plaque; however, nutrients do diffuse into the plaque. Bacteria in plaque ferment sugars and amino acids to produce energy (Hillson, 1986). Plaque grows faster from sucrose than other sugars (e.g., fructose or glucose) (MacPhee and Cowley, 1975). Starch molecules are too large to diffuse into plaque. However, if starch remains in the mouth, it may be broken down by an enzyme present in the saliva (Navia, 1980).

Plaque mineralization begins at the base of the living deposit and is attached to the tooth surface. Early deposits form within ameloblast pits and perikymata (Hillson, 1996; Scheie, 1989). Deposits begin as a calcium/phosolipid/phosphate complex (CPLX) within the bacterial plaque matrix, which supports subsequent hydroxyapatite deposition (Boyan et al., 1989).

Both sub- and supra-gingival plaque may become mineralized. Minerals in supra-gingival calculus are derived from the saliva. Thus, sites closest to the salivary glands (i.e., the lingual surfaces of anterior teeth and buccal surfaces of the molars) usually exhibit the most calculus. Minerals for sub-gingival calculus most likely come from crevicular fluid that seeps from the gums around the base of the teeth (Driessens and Verbeeck, 1988; Williams and Elliot, 1979). Calculus minerals include phosphates such as apatite, whitlockite, brushite and octacalcium (Driessens and Verbeeck, 1988; Swärdstedt, 1966), although the proportions of these minerals vary at different oral pH values (Driessens and Verbeeck, 1988).

Calculus in Egypt

Little can be said about the amount of calculus exhibited by Predynastic Egyptians based on the current literature. Nearly 60% of 7th to 1st century BC individuals at Abusir had calculus deposits. The deposits are most often narrow bands on the buccal sides of the lower teeth (Strouhal, 1984). Ibrahim (1987) examined samples from 26th to 30th Dynasty Giza, 7th, 20th and 30th Dynasty Hawara, 9th Dynasty Sidmant, early Predynastic Badari, Predynastic and 1st Dynasty Abydos, Predynastic to Protodynastic El-Amra, Predynastic Naqada, Christian Biga, New Kingdom Shallal, and 1st to 12th Dynasty Kerma. There was no difference between the sexes in the amount of calculus formation. Calculus severity increased to the 41-50 year age category, after which there was a decrease, possibly related to some occupational behavior as demonstrated at Hierakonpolis in the current study. In all age categories the Predynastic groups showed the greatest incidence and degree of calculus deposition. Groups from Upper Egypt tended to have more calculus than those from Middle Egypt, however the only significant difference was in the 21-30 year age group (Ibrahim, 1987).

Abscess

An abscess is defined as a hole filled with pus that results from a local infection. In dry bone, the abscess appears as a hole or cavity in the bony tissue leading to the alveolus (see Figure 5.3). Bony lesions occur as a result of the infection, or pus, attempting to drain. Borders of the lesion appear porous or rough rather than sharp, distinguishing it from ante- or post-mortem trauma or taphonomic alterations (Hillson, 1986).

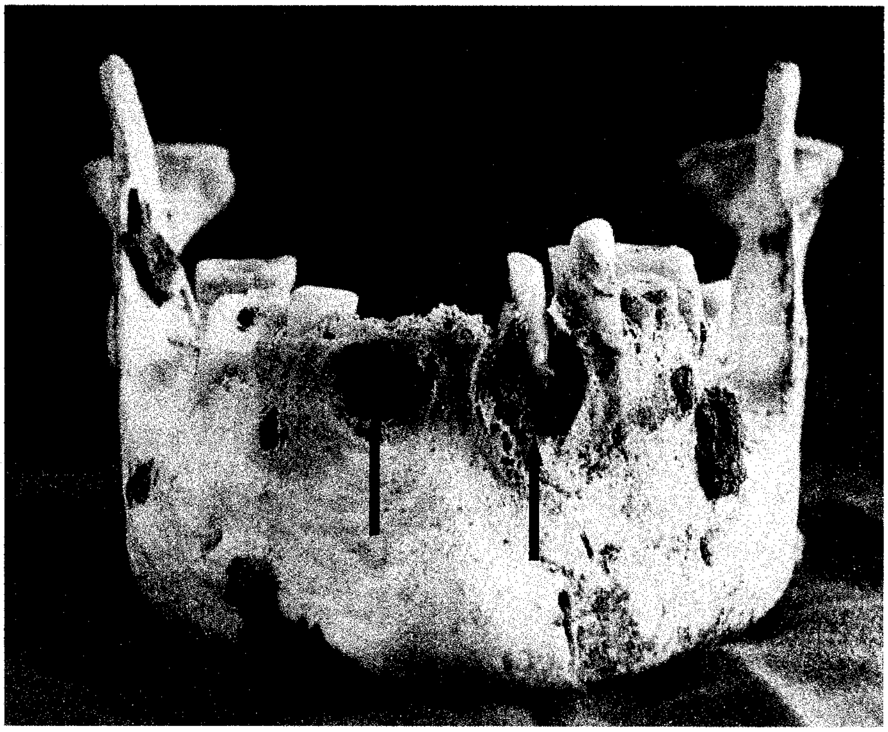

Figure 5.3: Abscess. Arrows point to abscesses on a mandible from Hierakonpolis. Width of photograph is approximately 13 cm.

Etiology

Pulp exposure inevitably results in infection and eventual formation of a dental abscess cavity. Infection results from the same oral bacteria responsible for dental plaque and carious lesion formation. Bacteria enter when the enamel is compromised so as to expose the pulp chamber to the environment (Linn et al., 1987). Enamel may be compromised by trauma to the tooth, macrowear or caries (Buikstra and Ubelaker, 1994; Clarke and Hirsch, 1991; Hillson, 1986), although abscesses may occasionally result from 'spontaneous idiopathic phenomena' (Buikstra and Ubelaker, 1994: 55).

The body's attempt to fight the bacterial infection results in the formation of pus, which consists mostly of white blood cells (Glanze et al., 1996). Pressure created as the pus accumulates destroys the surrounding bone. Draining of the pus through an abscess helps the body to eliminate the infection. The abscess usually occurs at the root apex, but bone destruction may extend upward along the periodontal structures (Clarke and Hirsch, 1991). For abscesses related to trauma or spontaneous phenomena, it is usually impossible to determine the underlying cause. Abscesses related to caries are a reflection of diet, while those related to macrowear may be a reflection of diet or use of teeth as tools (Clarke and Hirsch, 1991).

Abscess in Egypt

In Egypt, the incidence of abscess increases through time. In the Predynastic sample from Hierakonpolis studied by Leek (1966), abscesses affected 2.3% of teeth. The prevalence rises to 4.2% of teeth for males and 4.5% for females by the 26th to 30th Dynasties at Abusir (Strouhal, 1984). Abscesses tend to occur most frequently in females (Leek, 1984; Podzorski, 1990; Strouhal, 1984). Leek (1984) found that among individuals who were members of the Pharaoh Cheop's court (c. 2650 BC) a greater number of males (41%) than females (32%) expressed abscesses. However, of the individuals affected, females had a greater number abscesses per mouth (12.0%) than males (8.0%). When compared by age categories, Ibrahim (1987) found that in individuals 50 and over, males have more abscesses than females in samples from 26th to 30th Dynasty Giza, 7th, 20th and 30th Dynasty Hawara, 9th Dynasty Sidmant, early

Predynastic Badari, Predynastic and 1st Dynasty Abydos, Predynastic to Protodynastic El-Amra, Predynastic Naqada, Christian Biga, New Kingdom Shallal, and 1st to 12th Dynasty Kerma.

Periodontitis

Clinically, periodontitis, or periodontal disease, is an inflammation of the gingiva and periodontal membrane. The effects can be seen on dry bone when the periodontitis progresses so far that alveolar bone is damaged (see Figure 5.4). Eventually, the tooth may loosen and be lost (Coventry et al., 2000). Bone loss associated with periodontitis may involve alveolar bone lining the tooth sockets, the outer cortical plates on buccal and lingual sides, and/or underlying medullary bone. Bone loss may occur in a horizontal or vertical pattern (Hillson, 1996).

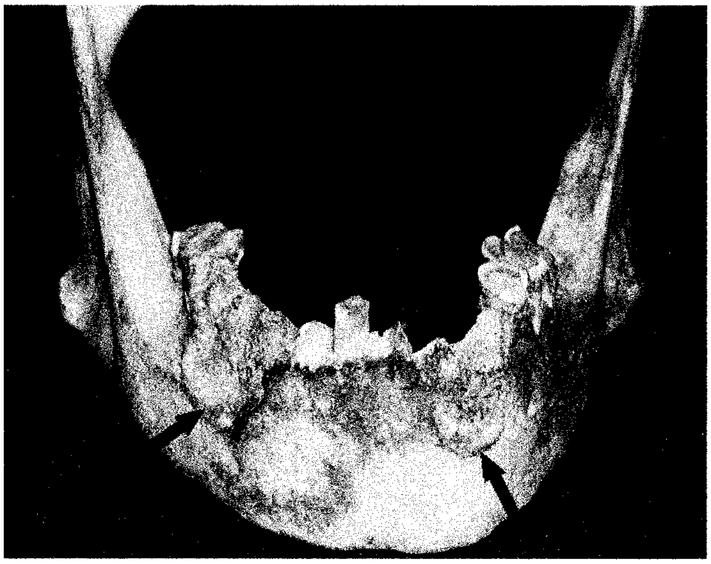

Figure 5.4: Periodontitis. Arrows point to periodontal bone loss on a mandible from Naqada. Width of photograph is approximately 13 cm.

Etiology

The notion that periodontitis is a natural progression of gingivitis came under dispute in the late 1970s. It is now generally accepted that there is no, or at best a very weak correlation between gingivitis and periodontitis (Coventry et al., 2000; Kerr, 1991; Neely et al., 2001; Smalley, 1994). As with caries and abscess, oral bacteria cause periodontitis. Normally, gingiva protects the bone from microorganisms in the mouth. However, calculus formation may act to slightly separate the gingiva from the tooth surface (Riethe, 1974). Calculus is always covered with plaque bacteria. As more calculus forms there is a greater surface area available to which plaque can adhere, which increases the chances for exposure of the periodontal tissue (Neely et al., 2001).

Bacteria associated with periodontitis include *Porphyromonas gingivalis, Prevotella intermedia, Prevotella melaninogenica, Bacterioids forsythus, Actinobacillus actinomycetemomitans* and *Peptostreptococcuss* (Coventry et al., 2000; Smalley, 1994; van der Velden et al., 1993). Enzymes produced by microorganisms directly disrupt the connective tissue matrix. *P. gingivalis* and *Peptostreptococcuss* produce chondroitinase- and hyaluronidase-like enzymes, which disrupt matrix glycosaminoglycan and proteoglycans. Proteases and peptidases from other bacteria act against natural substrates, such as collagen, fibroblast cell surfaces and matrix glycoproteins. *P. gingivalis, P. intermedia, P. melaninogenica* and *A. actinomycetemomitans*, release extra-cellular membrane vesicles. The vesicles immobilize and kill netophils, which may indirectly add to tissue destruction if lysosomal enzymes are released (Smalley, 1994).

Chronic inflammation of the periodontium, caused by bacteria, often leads to reduced blood flow that deprives the area of nutrients. Lack of ascorbate and other essential metabolites may compromise the repair of collagen. Phagocytosis may also be reduced by lack of ascorbate (Smalley, 1994).

Research has established that the mere presence of bacteria, even in large amounts, does not necessarily lead to periodontal attachment loss. Certain factors such as age, genetics, and access to fluoride are believed to effect susceptibility to periodontitis. A number of studies report that periodontitis increases with age; however, the association may not be as significant as some suggest (Neely et al., 2001; Ong, 1998). Larato (1970) found that while the number of bony defects per skull increased with age, the number of individuals affected did not. In a similar study, Page and Beck (1997) conclude that periodontal disease is age-associated rather than a consequence of aging. There is no evidence to suggest that increased age makes periodontal tissues more susceptible to breakdown. Periodontitis is more closely related to exposure to risk factors over time rather than to age per se (Neely et al., 2001; Ong, 1998).

Studies have attempted to find genetic links to periodontitis using ABO blood type (Polevisky, 1929) and secretor status (Pradhan et al., 1971) with little success. More recent studies considered early onset periodontitis and found evidence for a genetic basis (Boughman et al., 1986; Corey et al., 1993). Studies on living populations show that monozygotic twins (23.0%) are significantly more concordant for periodontal disease than dizygotic twins (8.0%), suggesting that genetic factors do influence the risk for periodontitis (Corey et al., 1993).

Studies suggest that fluoride may decrease the risk for periodontal disease. Fluoride most likely decreases the adherence of plaque or inhibits plaque. Fluoride is known to reduce caries. Fewer carious lesions mean fewer restorations in modern populations. Dental restorations may themselves lead to periodontal disease by causing the gingiva to recede from smooth surface or inter-proximal fillings (Grembowski et al., 1993).

Certain nutritional deficiencies also increase the risk of periodontal disease. Deficiency of vitamin D may cause slowed bone formation. Lack of vitamins A, B complex, and C, may reduce resistance of tissues to irritation and infection. However, only prolonged deficiency of vitamin C, leading to scurvy, has any demonstrable effects on periodontitis (MacPhee and Cowley, 1975).

Periodontitis in Egypt

Only a few studies consider periodontitis in Egypt. Ruffer (1920) concluded that periodontal disease was rare in ancient Egyptians. Leek (1966) examined collections from Pre- and Early Dynastic Hierakonpolis, the 1st and 2nd Dynasty from Tarkhan, the 4th to 18th Dynasty from Qaw, the 9th Dynasty from Sidmant and the 11th Dynasty from Qurna. In Predynastic populations periodontitis affected 6.6% of teeth. The prevalence drops to between two and three percent in the Dynastic (Leek, 1966). In Predynastic Egyptians from Naga-ed-der the frequency of periodontitis was found to be two times higher in females than in males; nine versus four (Podzorski, 1990:57).

Hypoplastic Enamel Defects

Hypoplastic enamel defects include various malformations on the crown surface from furrows to pits (see Figure 5.5) that represent episodic disruptions of enamel matrix secretion during growth (Goodman and Armelagos, 1985b, a; Goodman and Rose, 1991). Hypoplastic enamel defects often coincide with accentuated striae of Retzius (microscopic 'Wilson bands'), which show the position of the active ameloblasts at the time of disruption. The surface profile of the tooth is altered due to a convergence of striae of Retzius as they approach the enamel surface and to abnormal prism structure along the defect. Because of the appositional nature of enamel the defect is often overlapped by normal enamel, resulting in locally thin but not necessarily absent enamel (Goodman and Rose, 1990; Pindborg, 1970).

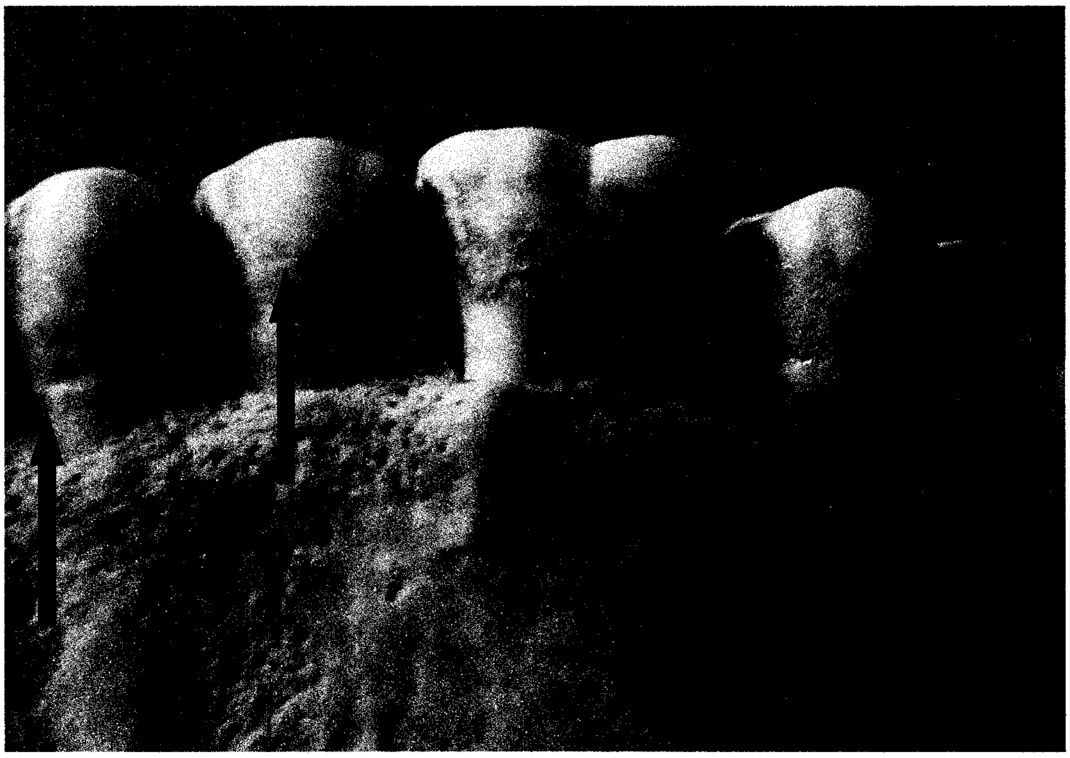

Figure 5.5: Hypoplastic enamel defects: Arrows point to hypoplastic defects on a maxilla from Hierakonpolis. Width of photograph is approximately 4 cm.

Etiology

Hypoplastic enamel defects tend to result from at least one of three causes, namely, hereditary anomalies, localized traumas, and systemic metabolic stress (Goodman and Rose, 1990; 1991; Pindborg, 1982). Hereditary anomalies are generally the most severe and usually affect all teeth in a set as well as entire tooth crowns. Hereditary hypoplastic defects may be either autosomal dominant or autosomal recessive (Gorlin and Goldman, 1970; Pindborg, 1970, 1982; Witkop and Rao, 1971). Both types cover the crown evenly with fine depressions (Gorlin and Goldman, 1970). Hereditary dental defects are rare, generally affecting less than one percent of individuals in most contemporary populations. Affected individuals tend to have other fatal congenital problems, such as epidermolysis bullosa dystrophica, pseudohypoparathyroidism, oculodentodigital dysplasia and/or mucopolysaccharidoses (Winter and Brook, 1975). Therefore, the frequency of affected people would likely be even less in prehistoric populations due to the lack of necessary medical treatment as these individuals would not survive to reproductive maturity (Goodman and Armelagos, 1985b, a; Goodman and Rose, 1990, 1991; Sciulli, 1978).

Defects attributable to local trauma, local inflammation and other non-systemic factors, usually called Turner teeth, are also extremely severe but not deadly. However, these factors usually affect single or a few adjacent teeth (Goodman and Armelagos, 1985b, a; Goodman and Rose, 1990, 1991; Sciulli, 1978). Due to deposits of cementum on the crown surface, Turner teeth tend to have a yellow or brown color. Turner teeth also tend to be smaller than normal and may have an overall abnormal morphology, making them readily distinguishable from teeth with hypoplastic enamel defects that result from systemic metabolic disturbances (Pindborg, 1970).

Most hypoplastic defects are caused by systemic metabolic stress (Goodman and Armelagos, 1985b, a; Goodman and Rose, 1990, 1991; Sciulli, 1978) and are typically referred to as linear enamel hypoplasias (LEH) because they tend to occur in a linear pattern. Linear enamel hypoplasias are characterized by a localized decrease in thickness of the enamel and are much more pronounced than perikymata, a normal outcropping of the striae of Retzius (Pindborg, 1970).

Histological and morphological studies suggest that LEH's result from non-specific physiological disruption during matrix secretion (Goodman and Rose, 1990; Pindborg, 1970; Sarnat and Schour, 1941). Research has linked many childhood stressors to hypoplastic enamel defect formation, including vitamin A and D deficiencies, fever, maternal diabetes, neonatal asphyxia, neonatal jaundice, nephrotic syndrome, gastroenteritis (Goodman et al., 1984b; Jontell and Linde, 1986) under- and over-nutrition, and hormonal changes (Goodman and Armelagos, 1985b). In fact, most stressors, if severe enough, can result in disruptions of enamel development (Goodman and Rose, 1991). However, in reality the combination of several stressors is necessary to form a defect. Teeth that develop while host resistance is low and environmental insults are high are more likely to have hypoplastic defects (Goodman and Armelagos, 1985a).

Amelogenesis may be disrupted at any time (Sarnat and Schour, 1941); however, the longer an ameloblast has been active the more likely it is to be affected by a physiological stress. Changes to ameloblastic function that occur early in the cell's life cycle simply cause abnormal secretion of enamel substance adjacent to and within the cell cytoplasm. While the resulting abnormality is irreversible, the cell may eventually return to normal function. Such disruption often is evidenced by slightly wider than normal striae of Retzius. If the stress continues or becomes more severe, vacuolar changes in the ameloblasts may result. Very severe stressors may completely destroy ameloblasts (Pindborg, 1970). Amelogenic disruption may happen in an episodic or chronic manner. Moreover, lack of enamel healing means that longer disruptions cause larger hypoplastic defects, thus hypoplastic defect size may reveal the severity and intensity of the disruption (Goodman and Rose, 1990; Pindborg, 1970).

Ameloblastic function is most often disrupted on the labial sides and in the middle thirds of tooth crowns. Hypoplastic enamel defects most likely appear more on the labial side for the same reasons perikymata occur more on the labial side. Greater relief on the lingual side may make extraneous grooves and pits more difficult to discern. At least 40% (first molars) to 50% (all others) of hypoplastic defects are found on the middle thirds of crowns. Distribution of defects is similar for all tooth crowns, regardless of time of development. The occlusal third is even less affected on posterior teeth than anterior teeth (Goodman and Armelagos, 1985a).

Several researchers have proposed explanations for the distribution of hypoplastic defects. One suggestion is that the number of active ameloblasts decreases toward the cervical half of the tooth, meaning that a stressor would have a greater effect on crown development nearer the root. However, there seems to be a resistance to hypoplastic events near the cemento-enamel junction (CEJ). Others suggest that the rate of crown development is greater in the middle and cervical thirds of the tooth (Gleiser and Hunt, 1955; Moorrees et al., 1963), which may make ameloblasts in these areas more susceptible to disruption. However, canines, which are among the slowest developing teeth, are also among the most hypoplastic (Goodman and Armelagos, 1985b).

A more probable explanation is that because enamel prisms are nearly perpendicular to the surface just cervical to the midpoint, variation in prism length may be easier to discern (Goodman and Armelagos, 1985a). Another explanation is that the longer an ameloblast has been active the more severely it will be affected by a stressor. Thus, the severity of response may be related to the distance from the DEJ (Goodman and Armelagos, 1985a). Ameloblasts in the middle third of the crown have a farther distance to travel from the DEJ, thus are active longer. The two explanations are not necessarily discordant.

While the area of a crown most susceptible to hypoplastic defects remains consistent from tooth to tooth, some teeth are generally more susceptible than others. According to Goodman et al. (1984a), maxillary central incisors and lower canines are most frequently hypoplastic. However, Pindborg (1970) states that incisors suffer severe structural defects less frequently than molars and canines. El-Najjar et al. (1978) found that the frequency of hypoplastic enamel defects is greatest in anterior teeth, intermediate in premolars and lowest in molars.

Crown heights may partially explain why some tooth types are more susceptible. After correcting for crown height, the maxillary central incisors decrease from 9.77 times more susceptible than the mandibular second molars to 6.50 times more susceptible

(Goodman and Armelagos, 1985b). Thus, the taller a tooth is, the longer it takes to grow and therefore has a greater chance of succumbing to stressors (Goodman and Armelagos, 1985b, a). However, differences in crown heights only account for a small portion of the differences.

There are a number of theories that attempt to explain variation in tooth-type susceptibility. Experiments are difficult to conduct because there is great variation in susceptibility among species, including primate species. Until recently, the most frequent explanation was the 'time-of-development hypothesis,' which states that the teeth most frequently affected correspond with teeth that are developing at the time of the most common stressor. If the time-of-development hypothesis is correct, all crowns developing at the time of the stressor should be equally responsive and therefore should all express the same defect. Tests of the time-of-development hypothesis found that teeth developing at the same time show different frequencies of hypoplastic enamel defects (Goodman and Armelagos, 1985b, a).

Goodman and Armelagos (1985b; 1985a) suggest that differences in frequency among tooth type are most likely related to developmental stability. That is, teeth whose development are under strongest genetic control are more likely to have hypoplastic enamel defects because they are less able to alter their developmental timing. Hypoplastic defects may be the only means of response for some teeth to environmental stressors. In other words, the ameloblasts of teeth under strictest control must keep moving, but cease matrix secretion in order to conserve energy. Teeth, such as polar teeth (maxillary central incisors, mandibular lateral incisors, canines, first premolars and first molars, as defined by Dahlberg's modification of Butler's field theory) that are able to decelerate the movement of ameloblasts in order to conserve energy, are less likely to become hypoplastic. Thus, the polar teeth are more likely to be hypoplastic (Dahlberg, 1945; Goodman and Armelagos, 1985b, a; Goodman and Rose, 1990). Goodman and Armelagos (1985b) found that in six samples studied, the polar teeth were more hypoplastic in every case.

Hypoplastic Enamel Defects in Egypt

Hypoplastic enamel defects have not been studied extensively in Egypt. Leek (1984) found no evidence of enamel hypoplasia in a sample from the Pharaoh Cheop's court during the 4th Dynasty. Hillson (1978) examined 941 individuals from Egypt and Nubia ranging from the Predynastic to Christian periods. Most cemeteries examined have a maximum frequency of 40% of individuals affected by hypoplastic defects, with no temporal trends. However, Badari (5000-3000 BC), Sidmant (2000 BC) and Hawara (AD 100-200:Roman) all have a peak of 70% or higher between three and five years of age. The higher peak may be due to susceptibility to childhood diseases, environmental or genetic predisposition (Hillson, 1978; Hillson, 1979).

CHAPTER SIX

TOOTH WEAR

In order to discern the relationship between tooth wear and diet, the biomechanics of mastication must be understood. Mastication is the act of reducing the size of ingested food items by chewing until a size that can be swallowed and easily penetrated by digestive enzymes is reached (Hiiemae, 1984). Chewing forces and occlusal morphology of the teeth interact with the physical properties of food to produce distinctive wear patterns (Maas, 1988). Mastication takes place on one side or the other of the mouth for a number of cycles, after which the active and balancing sides are reversed (Hiiemae, 1978).

While there are several variations in the terminology used to describe mastication, terms suggested by Hiiemae (1978) are widely accepted and are used here. Hiiemae (1978) divides the masticatory cycle into four sequential stages (see Figure 6.1). Beginning at maximum gape, these stages are fast close, slow close, slow open and fast open. These stages reflect the movement of the mandible, cranial flexion and extension and movement of the tongue and hyoid complex. Motion of the jaws and cranium during mastication makes up three functional strokes: the closing stroke, the power stroke and the opening stroke.

Beginning at maximum gape, the closing stroke brings the lower molars into alignment with the uppers. While this stroke is predominantly vertical, there may be varying degrees of lateral movement dependent on the position of maximum gape relative to the midline. In humans, the maximum gape may occur on the balancing side, active side, or at the midline. There is also a small degree of antero-posterior movement in order to bring the molars into position for the power stroke (Hiiemae, 1978).

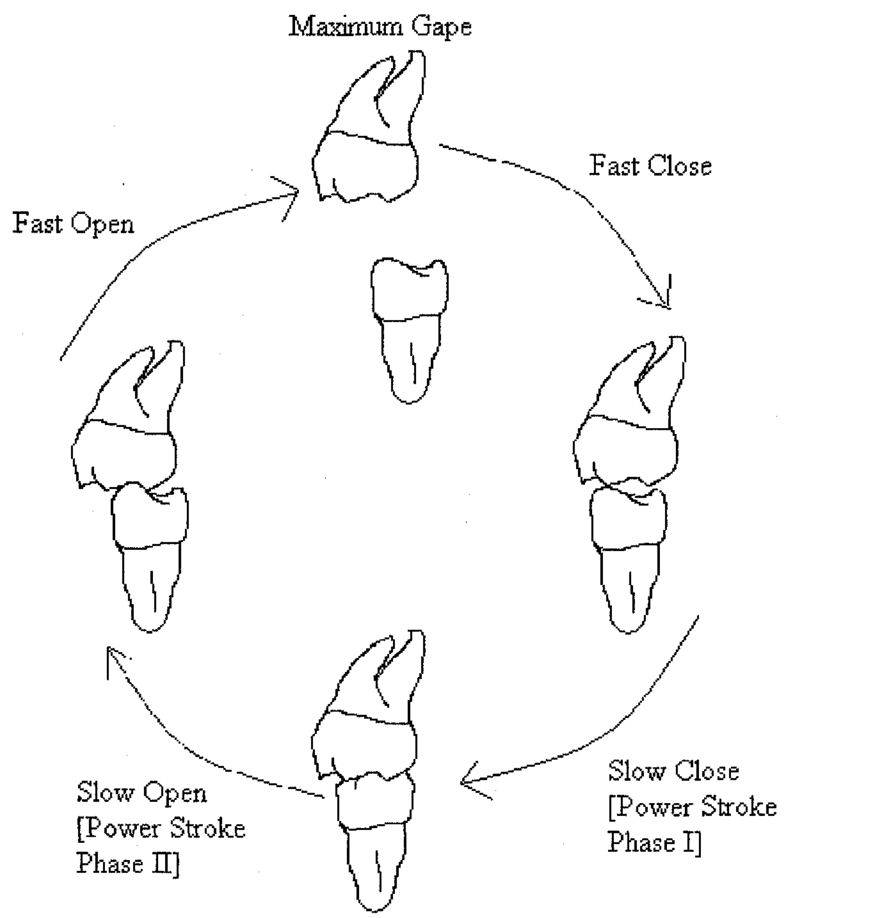

Figure 6.1: Stages of mastication. Adapted from Hillson (1996).

The power stroke, which comprises about 22% of the masticatory cycle, begins with a change in velocity from fast close to slow close. The power stroke is divided into two phases: Phase I and Phase II. During Phase I, the mandible moves from buccal to lingual (of the active side) and upwards toward centric occlusion (Hiiemae, 1978). However, the verticalness of this movement decreases as molar wear increases (Beyron, 1964). Phase I is completed when the teeth are in or near centric occlusion (Hiiemae, 1978).

Phase II is an infero-medial movement from centric occlusion (Kay and Hiiemae, 1974) and encompasses part of the slow open stage. This movement is required for the lower molar cusps to clear the uppers at the beginning of the opening stroke (Hiiemae, 1978). The opening stroke begins with the slow open when the mandible is in a slightly forward position and shifts to fast open to return the mandible to maximum gape. This may be a strictly vertical movement or cross the midline (Hiiemae, 1978).

Although Phase I and II are part of a continual masticatory cycle, they are characterized by consistent differences. These differences have led some to refer to Phase I as the puncture/crushing phase. Phase II, is sometimes referred to as grinding. Technically, Phase I and Phase II are defined in terms of movement into and out of centric occlusion, respectively, while puncture/crushing and grinding are defined in terms of direction of force in relation to contact areas between tooth surfaces. Therefore, the terms should not be used interchangeably (Maas, 1988).

Puncture crushing is predominant during the early part of the masticatory sequence, when the bolus is fairly large. During puncture/crushing, food is punctured or crushed and the teeth do not come into occlusion. As the food particle size is reduced during grinding, the teeth come closer together until they finally occlude (Hiiemae, 1976). During puncture/crushing the power stroke has greater vertical amplitude and a lesser transverse component than during grinding (Hiiemae, 1978; Hiiemae and

Crompton, 1985). Also, the closing stroke is slower and the opening stroke faster during puncture/crushing than grinding (Kay and Hiiemae, 1974).

Microwear

As dental hard tissues are worn away, the material causing the wear leaves microscopic pits and scratches on the enamel surface (see Figure 6.2). Patterns of these microscopic wear features, can be viewed and recorded using a scanning electron microscope (SEM), and reflect dietary composition (Harmon and Rose, 1988; Puech, 1986; Teaford, 1991, 1994). Pits are defined as features with a length-to-width ratio equal to, or less than, four-to-one (Teaford and Walker, 1984; Teaford, 1991). Scratches are narrow striae, usually created by grit particles (Teaford and Walker, 1984; Walker et al., 1978). Lack of microwear features is known as polish. Absence of pits and scratches makes these areas appear flat; however, the polished ends of enamel prisms may also be visible as raised rounded mounds (Harmon and Rose, 1988). Polish is usually caused by silica in a vegetable rich diet (Puech et al., 1983; Walker et al., 1978), but may also result from very small grit particles in plant fiber (Puech et al., 1983).

Location of Microwear

Dental microwear analysis for dietary reconstruction is generally conducted on the Phase II wear facet of the protoconid of the left mandibular second molar (Teaford, 1991). Wear facets on the teeth are named after the phases of the power stroke (Phase I and Phase II wear facets) during the chewing cycle. However, this nomenclature is slightly misleading.

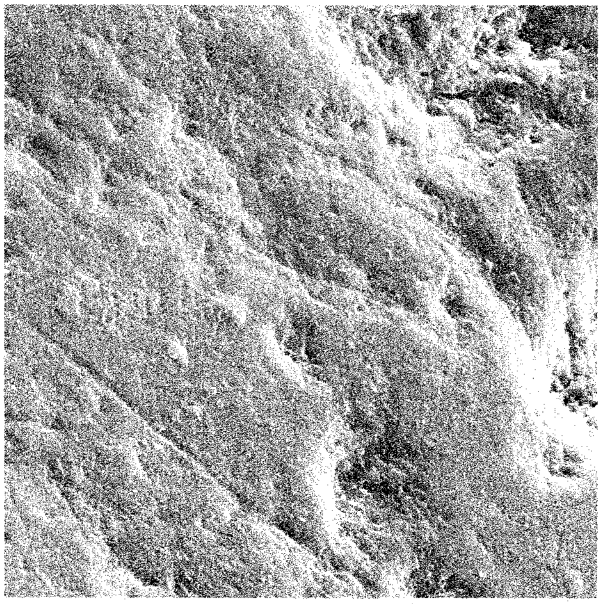

Figure 6.2: Microwear image (500x) from Hierakonpolis. Image area is $0.25mm^2$.

Differences in the size of food particles are responsible for different types of wear and for wear at different locations on the tooth. Phase I wear facets are caused by food-tooth contact during puncture/crushing early in the mastication cycle. These facets are located on the buccal aspects of mandibular molar cusps and the lingual aspects of maxillary molar cusps. Phase II wear facets are caused by tooth-food and possibly some tooth-tooth contact during grinding later in the masticatory cycle. Phase II facets occur on the lingual aspect of mandibular molar buccal cusps and the buccal aspect of maxillary molar cusps (Kay, 1977; Muendel, 1997). Some researchers consider wear produced during Phase I abrasion and wear produced during Phase II attrition (Kay and Hiiemae, 1974), while others consider all diet related wear attrition (Brothwell, 1981; Hillson, 1986).

Microwear Analysis

Microwear images are obtained using a scanning electron microscope (SEM). A SEM creates an image by shooting a beam of focused electrons onto the surface of an electrically conductive specimen. As electrons strike the specimen, they give off a variety of signals. Low energy, secondary signals from the uppermost layer of the specimen are collected by detectors and translated into a series of pixels. For each point where the electron beam strikes the specimen, a corresponding pixel is displayed. The brightness of the pixel is directly proportional to the number of electrons generated from the specimen surface (Bozzola and Russel, 1992).

Different researchers have used a variety of magnifications for microwear studies. Some researchers prefer a low magnification (100x – 200x), while others prefer a high magnification (1500x) and still others prefer a magnification in between (500x). Low magnifications allow for viewing a greater area, but do not have the resolution of higher magnifications. High magnifications allow for greater resolution, but one may examine a smaller area of the tooth (Gordon, 1988b). A medium magnification, such as 500x allows for a larger area than 1500x but with greater resolution than 200x (Fredericksen, 2000).

Statistical analysis of the measurements of pits and scratches allow for inferences about dietary similarities among samples (Muendel, 1997). Measurement of the microwear features has become a much faster and easier process with the use of

Microware 4.0, a computer program developed by Peter Ungar (2002). This program allows microwear features to be measured with a computer mouse from digital images, eliminating the use of rulers, protractors and acetate sheets. The computer requires the user to select four points per microwear feature: the two ends of each major and minor axis. From these points, the computer determines the major axis length, major axis slope, minor axis length and minor axis slope and counts the number of features. The computer also calculates the major axis length mean, major axis length standard deviation, minor axis length mean, minor axis length standard deviation, preferred orientation mean, preferred orientation standard deviation, major/minor axis ratio mean, major/minor axis ratio standard deviation, number of features, pit tally, pit length mean, pit length standard deviation, pit width mean, pit width standard deviation, scratch tally, scratch length mean, scratch length deviation, scratch breadth mean, scratch breadth standard deviation, scratch orientation standard deviation and scratch concentration (Ungar, 2002). The significance of these calculations is discussed below. Because the program distinguishes between pits and scratches based on length/width parameters, inter-observer error is greatly reduced.

Along with the statistical analysis of pits and scratches, some researchers find the qualitative analysis of polish and striation margin morphology useful (Harmon and Rose, 1988; Puech et al., 1983). Striation margin morphology refers to the relative sharpness, roughness and roundness of the margins (Harmon and Rose, 1988).

Microwear in Dietary Reconstruction

Although the initial and most extensive study of dental microwear for dietary reconstruction has been conducted on early hominids and primates (e.g., Gordon, 1982b; Grine, 1981, 1987; Lalueza-Fox et al., 1996; Teaford, 1994; Ungar, 1996; Walker, 1981), more researchers are now examining microwear on teeth from prehistoric human populations (Harmon and Rose, 1988; Molleson et al., 1993; Muendel, 1997; Schmidt, 1998). The size and shape of microwear features provides clues as to the size, shape, and hardness of the abrasive particles that cause them (Gordon, 1982a; Grine and Kay, 1988; Teaford, 1991, 1994). Lucas and Teaford (1995) have shown that microwear patterns in primates reflect seasonal differences, as caused by seasonally available foods, and that occlusal microwear patterns can be used to distinguish subtle differences in diet. Walker (1978) found that *Procavia johnstoni* (hyrax) exhibits polish during browsing seasons (bushes and trees) and numerous fine scratches during grazing (grasses) seasons. Teaford and Runestad (1992) showed that soft fruit eaters such as *Alouatta* exhibit small pits while *Cebus*, which eat invertebrates and other hard objects, exhibits large pits.

Statistical analysis of the measurements of pits and scratches can reveal dietary similarities between samples (Muendel, 1997). For example, not all pits are formed in the same manner. Larger pits (>4 microns) are caused by the compression of hard objects, whereas smaller pits (<4 microns) result from tooth-on-tooth contact (Teaford and Runestad, 1992).

In regard to human diet, it is not yet possible to identify particular types of food, specific food processing techniques, or environmental factors based solely on microwear.

However, measurements such as pit length and width and scratch length, breadth and orientation, may be compared to a known array of available foods to determine which foods were most likely to have caused the observed patterns. This type of analysis can help to determine whether items that are believed to be food remains from the archaeological record where actually consumed in daily life, and whether different segments of a population consumed the same types or proportions of these foods.

Harmon and Rose (1988) found a high frequency of pitting associated with the consumption of hickory nuts, as implied by remains of roasted nuts in habitation and midden areas, in North American populations. However, a decrease or absence of pitting (Marks et al., 1985; Rose, 1984; Rose and Marks, 1985; Teaford, 1991) and increasingly coarse microwear features (Pastor, 1994) are seen after a dependency on maize agriculture is established. Gordon (1986) found coarse microwear with broad scratches, large pits, and featureless surface ‘roughening’ among prehistoric Zuni maize agriculturalists. She also noted many fine scratches and numerous small pits on the teeth of Eskimos, who consumed predominantly marine mammals (Gordon, 1986). Groups that eat cooked cereal grains and meat have high densities of small pits and fine shallow scratches while those that eat dry grain or seeds have a low number of larger scratches (Molleson et al., 1993). A high degree of polish associated with rapid attrition (macrowear) is indicative of a diet high in vegetable fiber (Harmon and Rose, 1988; Marks et al., 1985).

Moore-Jansen (1982) found numerous large scratches with evidence of polishing on teeth from a prehistoric site in eastern Oklahoma. Rose and Marks (1985) attribute the scratches to the use of stone grinding implements and consumption of shellfish, and the polishing to consumption of large quantities of vegetable fiber and seed husks. At a more recent site from the same area, teeth exhibited a high frequency of scratches, but no polishing and very little pitting (Rose et al., 1981). This microwear pattern was attributed to consumption of a soft, non-abrasive diet with contamination by dirt (Rose et al., 1981; Rose and Marks, 1985). Similarly, a diet of seeds and other plant material processed with stone utensils is evidenced by large, sharp scratches and numerous small pits at a prehistoric Arkansas site (Blaeuer and Rose, 1982).

Even when available foods are unknown, patterns of microwear features can be partially correlated with general subsistence patterns and select food preparation techniques (Pastor and Johnson, 1992; Peters, 1982). For example, folivorous primates have numerous long and narrow features with few pits and many visible enamel prisms, while frugivorous primates that feed on hard fruits have shorter and wider features with much pitting but few visible prisms (Teaford and Walker, 1984). Thus, even if exact foods are not known, it is possible to distinguish a folivor from a frugivor. In a blind study, Teaford and Lytle (1996) found microwear differences in a subject who ate sandstone-ground cornmeal versus hard-ground cornmeal.

Pit density corresponds to relative quantity of hard items in the diet, (Teaford and Walker, 1984; Van Valkenburgh et al., 1990) while pit size reveals the degree of crushing required for pulverization (Molleson et al., 1993; Ryan, 1979). Soft food produces more tooth-to-tooth contact (Ahlgren, 1966) and should therefore lead to a higher frequency of striations (Molleson et al., 1993). The combination of few microwear features with a high frequency of small pits and fine striations suggests consumption of soft food, while few features and a low pit density suggests consumption of food with inclusions that require crushing, such as inorganic inclusions in bread (Molleson et al., 1993).

However, there are caveats. Muendel (1997) found a wide variety of microwear patterning in a pre-contact population from Tennessee and concluded this was due to a large diversity of food types in the diet. Thus, more food choices lead to more microwear variation within a population. Food items that require the most chewing are likely to leave the dominant impressions on the teeth. For example, because dry cereals are more abrasive than meat, the dominant microwear pattern may be that of cereal even though it is not the most important part of the diet (Molleson et al., 1993). Very acidic foods, such as citric fruits, can alter the enamel surface so that it is more easily scratched (Lucas and Corlette, 1991; Molleson et al., 1993; Teaford, 1988a). Teeth of older individuals may exhibit lower feature densities but exhibit the same relative proportions of different feature types, than those of juveniles and younger adults (Gordon, 1982a, 1984b; Molleson et al., 1993). If sample size permits, controlling for macrowear and/or age should correct this problem. However, because changes in microwear occur over a matter of days or weeks, microwear analysis can only provide information about the diet at or shortly before the time of death (Teaford, 1991). With large enough samples, this may actually help to establish seasonality of death.

Microwear in Egypt

To date, Puech (1986) has been the only researcher to examine the microwear on Predynastic Egyptian teeth from Upper Egypt. These teeth show fewer striae than would be expected based on the severity of macrowear, and Puech (1986) concluded that the diet must have contained abrasive particles that also exerted a polishing action. Consumption of plant matter with phytoliths has been shown to produce a great degree of wear, but also acts to polish the enamel surface (Puech, 1986).

Macrowear

While some early studies considered macrowear a pathological condition, more recent research has shown that dental wear is a natural result of tooth function during mastication (Molnar, 1972). Wallace (1975) defined dental wear as the loss of enamel, dentine and cementum due to a combination of abrasion, erosion and attrition. Abrasion is caused by non-masticatory materials introduced into the mouth, or from abrasive non-food particles in the diet. Abrasion from non-masticatory use of teeth as tools is most likely to be seen on the anterior teeth. Erosion is the loss of dental tissues through chemical dissolution (Larsen, 1997) and may typically be seen as a shallow defect on the buccal surface (Ganss et al., 2002). This type of loss result from acids in the diet (e.g., citric fruits and soft drinks) or disease (e.g., gastric reflux disease and chronic regurgitation) (Chuajedong et al., 2002).

Dietary reconstruction is most concerned with attrition. Dental attrition is defined as the wearing away of dental hard tissues due to chewing. Attrition may be caused by the grinding of crowns against one another, or contact with food, cheeks and tongue (Hillson, 1986). While dietary reconstruction tends to focus on occlusal wear, it should be noted that teeth also wear interproximally (between teeth) due to continual side-to-side contact. The rate of occlusal wear is dependent on the overall morphology of the crown, the nature of the diet and behavior (Brothwell, 1981). Figure 6.3 depicts various stages of occlusal wear.

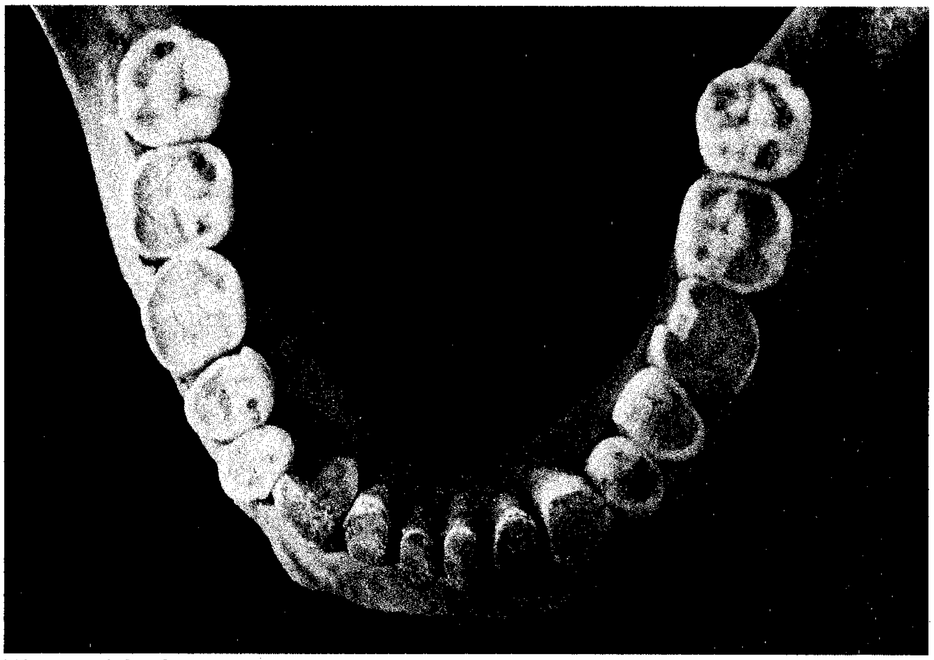

Figure 6.3: Occlusal wear. The incisors show the most severe stage of wear with little to no enamel remaining. The third molars show the least amount of wear with considerable enamel remaining. Photograph is approximately 9 cm.

Non-food particles in the diet, such as sand or grit, result, by definition, in abrasion (Larsen, 1997). This type of abrasion is difficult to separate from attrition, and because of its close relation to diet the distinction is rarely necessary. The remainder of this chapter deals solely with dental attrition. References to the abrasive properties of foods should not be confused with dental abrasion as a cause of macrowear. Likewise, wear resulting from non-food particles in the diet, such as grit from food preparation, is treated as attrition.

Causes of Macrowear

Everything that is ingested comes into contact with the teeth and can potentially leave a signature on the occlusal surface. Plants contain materials such as cellulose and lignin that cause dental wear. Meat is less abrasive than plant material, but chewing it still causes some wear. Bones that are chewed and chitin from insect exoskeletons also have an abrasive effect on dental tissues and there may be aspects of the diet other than the food itself that cause wear. For example, atmospheric dust or soil adhering to food and mineral particles from stones used for preparation of food also create wear (Hillson, 1986).

Diet alone cannot account for the extent or rate of attrition. Other variables include: the structure and hardness of enamel, the load applied to opposing surfaces (bite force), the quality and quantity of lubricant (saliva), oral pH, temperature of the teeth (altered by food temperature), relative speed of movement of opposing surfaces and the direction of movement of opposing surfaces (Kaidonis et al., 1998). Some factors such as saliva, oral pH and tooth temperature may vary greatly from meal to meal, but the structure and hardness of enamel, relative speed and direction of movement (Hiiemae, 1978) and bite force (Ahlgren, 1966) should remain relatively consistent.

Saliva acts as a buffer to the enamel. The rate of wear on dry teeth is significantly greater than teeth with saliva present. Fortunately, this condition tends to affect only a few individuals rather than entire populations (Kaidonis et al., 1998) and affected individuals would also have an unusually high rate of carious lesions (Applebaum, 1932). However, the quality of the saliva is also important. Low protein consumption creates saliva with a low pH (acidic oral environment) (Hillson, 1979), which produces a greater rate of wear than saliva with a neutral pH (Kaidonis et al., 1998).

Results of Macrowear on the Dentition

Regardless of the rate or cause of wear, most individuals show certain patterns in the stages of wear of each tooth and in the amount of wear on one tooth relative to another. The buccal aspect of the mandibular and the lingual aspect of the maxillary first and second molars show the greatest wear. Of the molars, the M1s typically exhibit the most wear. Because M1's erupt first (approximately age six), they are in use for the longest time (Hillson, 1986, 1996; Lavelle, 1970; Scott, 1979b).

In the early stages of dental wear the cusps become blunted and eventually flattened. Once the cusps are flattened, dentine becomes exposed causing an increase in the rate of wear. The patches of exposed dentine eventually coalesce into one large dentine patch that covers most of the crown surface. The thin rim of enamel around the dentine ultimately wears away leaving only dentine (Molnar, 1971; Scott, 1979a; Smith, 1984). If the tooth continues to wear the pulp chamber may be exposed, leading to possible infection or loss of the tooth (Linn et al., 1987).

The teeth do have some defenses against the progression of wear. Super eruption is the continued eruption of the teeth into the mouth. As the crown wears, the entire tooth is pushed higher in order to remain in occlusion and bone continues to be deposited along the alveolar crest (Ainamo and Talari, 1976).

Another defense against dental wear is the formation of secondary dentine. Physiological secondary dentine is an age-related, continual process of dentine formation around the pulp chamber walls and is almost indistinguishable from primary dentine. Reparative secondary dentine (Kuttler's tertiary dentine) is laid down in response to penetration of the enamel and exposure of the primary dentine (Kuttler, 1959). Addition of the secondary dentine acts to slow the rate of wear and extend the life of the tooth (Hillson, 1996; Kuttler, 1959).

Macrowear in Dietary Reconstruction

The value of dental wear research in the reconstruction of prehistoric behavior is well documented (Molnar, 1972). Examination of patterns of dental attrition has revealed inter-populational variability. This variability is known to be a reflection of diet, food preparation techniques and subsistence modes (Schmucker, 1985). Depending on food preparation techniques, as agriculture intensifies, producing softer diets, the severity of dental wear may decrease (Smith, 1984). However, Leigh (1925) found agriculturalists with a great deal of grit introduced through stone grinding implements to have a greater degree of wear than hunter-gatherers.

The degree of attrition may also affect and reflect the health of an individual. Severe attrition may limit the types of foods able to be consumed. Likewise, comparisons of food particle size and composition in feces suggest that digestive efficiency may be significantly reduced with worn teeth because they are less able to effectively pulverize food (Gipps and Sanson, 1984; Lanyon and Sanson, 1986; Sanson, 1985).

Macrowear in Egypt

While attrition in Egypt tends to be severe in all time periods, there is an increase in severity over time (Armelagos, 1969; Beckett and Lovell, 1994; Greene et al., 1967; Grilletto, 1973; Hillson, 1978; Ibrahim, 1987; Leek, 1966), and males usually show more severe attrition than females in all time periods (Leek, 1966; Strouhal, 1984). Leek (1969; 1972) attributed the severe attrition in Egyptian dentitions to the methods of flour and bread production. Ancient Egyptian bread was found to contain desert sand and rock fragments from the grinding stone used for processing flour that would quickly wear away the enamel (Leek, 1972). It is, however, unclear whether the cause of more severe attrition in males can be attributed to differences in bread or flour consumption or whether some other factor is responsible.

CHAPTER SEVEN

MATERIALS AND METHODS

Materials

Here dentitions from two populations, Hierakonpolis and Naqada are studied. While both sites have a long history of occupation ranging from the Paleolithic to Dynastic times, all individuals examined date to the Predynastic period, when Hierakonpolis and Naqada grew into the first large cities, possibly city-states of Egypt (Shaw, 1997).

Individuals included for study from both sites are believed to be members of the working class population. While the cemeteries at smaller sites in Egypt are typically socially unsegregated, those at large towns (i.e., Hierakonpolis and Naqada) reflect clear signs of social stratification. Burials of different size, shape, construction, and content are located in geographically separate cemeteries. Consideration of the working class samples is useful for three reasons: (1) They are generally the most numerous and yet the most overlooked for study; (2) While the higher status of the elite cemeteries at Hierakonpolis can be inferred from burial style and some remaining grave goods, extensive looting over the centuries has rendered most biological analyses of that segment of the population impossible; and (3) The working class generally gives better ideas of what life was really like as well as the wealth of land resources.

Hierakonpolis

Individuals from the working class cemetery, HK43 (Figure 7.1), are examined in this study. All skeletal remains are housed on site, under the care of the Hierakonpolis expedition. As of 2006, 469 burials with 512 individuals have been excavated; however, the cemetery itself appears to be much larger. Excavations were undertaken from 1996 to 2004 by Renee Friedman. All parts of the bodies and burial record were retained. These burials, as determined from their ceramic inventories date from Naqada Ic to Naqada IIc (3800 – 3650 BC), possibly dating as late as Naqada IID (3800 – 3300 BC) (Friedman, 1999, 2002). Of these 512 individuals, 196 with teeth present are considered here.

The Hierakonpolis sample used for this study includes males and females ranging in age from one year to over 50 years of age. Individuals aged one to six years were excluded because there are no members of that age group available for comparison from the Naqada sample. Table 7.1 summarizes the age and sex details for the individuals used. Sub-adults account for 16% of the sample. Forty-six percent of the adult sample is male and 54% is female. Of the adult sample, 68% are in the 18-35 year age category, 21% are in the 35-50 year age category and seven percent are over 50 years of age. Age could not be accurately determined for four percent of the sample.

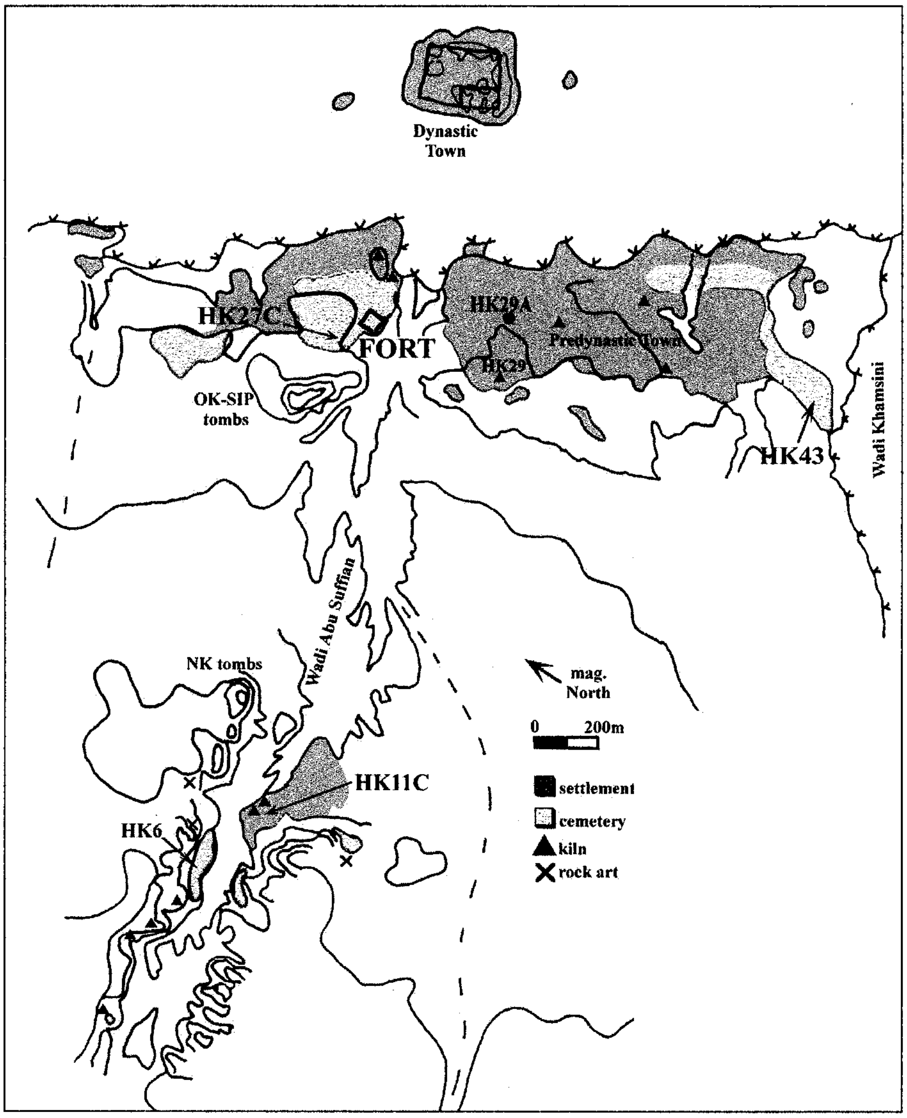

Figure 7.1: Hierakonpolis site map. (Map prepared by Renee Friedman)

Table 7.1: Frequency of sampled individuals from Hierakonpolis (HK43).

AGE	MALES	FEMALES	UNKNOWN	TOTAL
6-12	---	---	9	9
12-18	---	---	23	23
18-35	44	57	11	112
35-50	16	17	1	34
50+	5	6	1	12
Adult age unknown	1		5	6
TOTAL	66	80	50	196

Naqada

Individuals from Cemetery N, also known as the "Great New Race Cemetery" (Petrie and Quibell, 1896), from Naqada are used in this study. Figure 7.2 shows the location of the cemetery in relation to the rest of the site. Skeletal remains from Naqada are housed at the Leverhulme Center for Human Evolutionary Studies at the University of Cambridge.

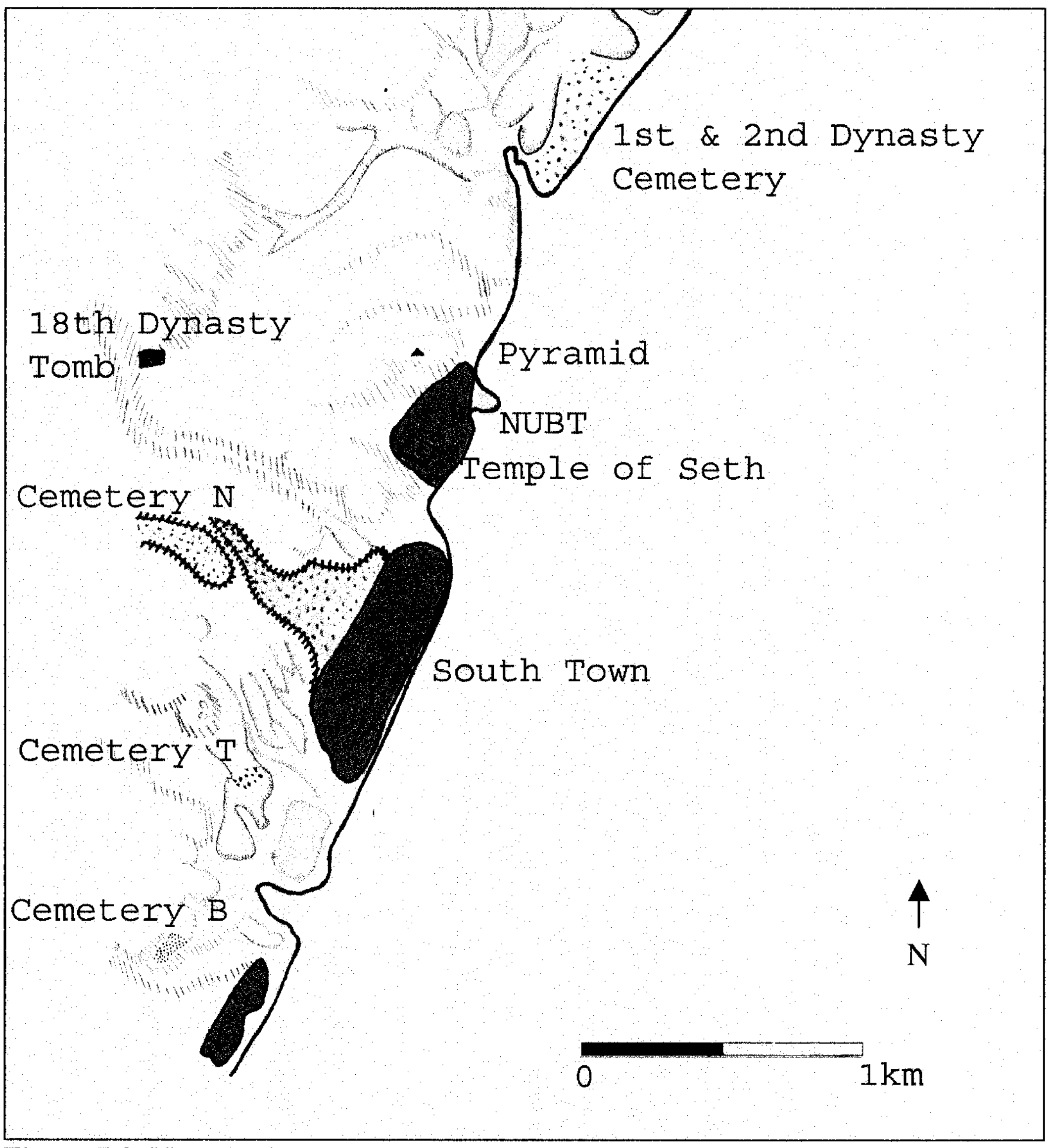

Figure 7.2: Naqada site map. Adapted from the Petrie Museum

Petrie (1896) excavated 1953 burials from Cemetery N. Before Petrie left for Egypt in 1894, he was asked "to procure…if possible 100 skulls of a homogeneous race" in order to conduct cranial-metric analysis (Fawcett and Lee, 1902: 411). However, Petrie actually sent the entire skeleton as well as crania of more than 400 individuals from Cemeteries N, B, and T, whose skeletons were the most complete (Fawcett and Lee, 1902) (the post crania are no longer available for study). Nowhere in Petrie's publications or in the publications of those who studied the collection in the early 1900s is there mention of the skeletons being selected on the basis of pathology, despite rumors recently circulated (i.e., Fawcett and Lee, 1902; Fowler et al., 1898; Petrie and Quibell, 1896; Warren, 1897).

From Cemetery N at Naqada, there are 168 individuals with dentitions. This sample consists of males and females ranging in age from six to over 50 years of age (see Table 7.2), and sub-adults account for 12% of the total. Forty-seven percent of adults are male and 53% are female. Of the adults, 13% are in the 18-35 year age category, 47% are in the 35-50 year age category and eight percent are over 50 years of age. Age could not be accurately determined for 31% of the sample.

These burials, are dated by pottery chronology and range in age from Naqada Ic to Naqada IIIa (3800-3200 BC), with the majority dating to Naqada II (Hassan, 1984). This is a slightly longer time span than for the Hierakonpolis sample. While many of the burials from Naqada are undatable, excluding these would create a sample size problem. The longer time frame is acceptable because (1) the dietary differences over the extended period should be negligible; and (2) the sample standard deviations for all tests run are quiet small and comparable to those at Hierakonpolis. Thus there is no more variation within the Naqada sample than there is within the Hierakonpolis sample.

Table 7.2: Frequency of sampled individuals from Naqada (Cemetery N).

AGE	MALES	FEMALES	UNKNOWN	TOTAL
6-12	---	---	5	5
12-18	---	---	10	10
18-35	7	13	---	20
35-50	39	32	1	72
50+	6	7	---	13
Adult, age unknown	21	25	2	48
TOTAL	73	77	18	168

Data Collection Methods

All individuals with teeth and/or bony sockets from the respective working class cemeteries were examined. Prior to dental analysis, teeth were cleaned with 95% ethyl alcohol and a cotton swab when necessary. Some teeth required reconstruction to increase the sample size; however, reconstruction was only undertaken when it would not bias the scoring. In some cases, due to the age of the remains, post-mortem loss or damage was so great as to exclude an individual from study for certain dietary indicators despite reconstruction attempts. In order to keep sample sizes sufficient, individuals were included on a per-indicator basis. For example, if an individual was missing all teeth but there was no damage to the bony sockets, that individual was included in counts for abscess, antemortem tooth loss, and periodontal disease. Criteria for inclusion within each indicator category are described below.

Subadult age is determined by dental eruption for both samples. At Hierakonpolis, where long bones are available for study, subadult age as determined via long-bone growth is consistently three to five years younger that of the dental age. Because dental formation is under stricter genetic control (Slavkin et al., 1984), only dental ages are used here for subadults. Adult age at Hierakonpolis is determined through pubic symphysis (Brooks and Suchey, 1990; Todd, 1921a; 1921b) and auricular surface changes (Ubelaker, 1989). In many instances, individuals had already been aged but on rare occasion, these ages were modified as necessary based on personal observations.

Cicely Fawcett and co-workers determined adult ages for the Naqada collection in the late 1800s and early 1900s, when the post-crania were available for study. Adult ages for individuals in this study were obtained from Fawcett and Lee (1902). Again, ages were modified based on personal observation where necessary, which occurred in less than 10% of individuals from either sample. Fawcett's publication does not contain ages for every individual, and due to the lack of post-crania a number of individuals were not aged beyond 'adult'. Age is divided into five categories: 6-12 years, 12-18 years, 18-35 years, 35-50 years, and greater than 50 years. The age category of one to six years was excluded because the Naqada collection contained no individuals under the age of six.

For the Hierakonpolis sample, sex was determined via a combination of pubic and cranial traits. Pubic traits include development of the ventral arc, presence of a sub-pubic concavity, shape of the ischiopubic ramus ridge (Phenice, 1969), width of the greater sciatic notch and appearance of the pre-auricular sulcus (Milner, 1992). Cranial traits include expression of the nuchal crest, mastoid process, supraorbital margin, supraorbital ridge and mental eminence (Acsadi and Nemeskeri, 1970). In several instances, individuals from the Hierakonpolis sample had previously been sexed but determinations were modified based on personal observation where necessary.

For the Naqada sample, sex was previously determined through analysis of pubic and cranial traits and published (Fawcett and Lee, 1902). Sex is also recorded on the boxes of remains. The sex of each individual from Naqada was confirmed via study of the cranial traits listed above and changed in only a few instances. Sex determinations for this study disagreed with those previously recorded in less than 10% of instances for both samples.

Carious Lesions

All fully erupted teeth were scored for carious lesions. Any tooth missing more than a quarter of its crown due to fracture was not scored. Any individual with greater than half of their teeth missing or damaged post-mortem was excluded. Antemortem tooth loss is acceptable and accounted for with the caries correction factor (Lukacs, 1995). Rudney et al. (1983) suggest that visual identification is more reliable than dental probe or radiographic techniques. Therefore, only lesions visible to the naked eye were scored, and following Moore and Corbett (1971) only lesions that penetrated the surface enamel were scored.

Carious lesion scoring followed standards presented by Buikstra and Ubelaker (1994). However, while they describe six locations (occlusal, interproximal, smooth surface, cervical, root and large), to increase sample size for statistical analysis it was necessary to collapse the location of the carious lesions into two categories: occlusal and non-occlusal. While not as precise as Buikstra and Ubelaker's (1994) categories, this categorization is appropriate as occlusal and non-occlusal lesions have different etiologies. Occlusal lesions tend to result from a diet high in carbohydrates whereas non-occlusal lesions result from a diet high in meat (Smith, 1986b).

Occlusal lesions occur on all grooves, pits, cusps and dentin exposures, including the buccal and lingual grooves of molars (Buikstra and Ubelaker, 1994). Non-occlusal lesions include Buikstra and Ubelaker's (1994) interproximal, smooth surface, cervical, and root caries. Large lesions were also scored, but are not considered regarding location, as their size makes it difficult to assign a surface of origin. Severity of the lesion was scored as small (pinprick to 1mm), medium (> 1 mm to ¼ of the tooth crown), large (> ¼ of the tooth crown, surface of origin cannot be assigned), or complete (complete or near complete obliteration of the crown).

Before calculating the frequency of carious lesions the caries correction factor (Lukacs, 1995) was applied (see Figure 7.3). This corrects for teeth lost antemortem due to carious lesions. While antemortem tooth loss may be due to destruction of the tooth by caries, once the tooth is missing the caries frequency is artificially lowered. The caries correction factor estimates the number of teeth lost due to caries by multiplying the number of teeth lost ante-mortem by the proportion of teeth with pulp exposure due to caries. The resulting number is added to the number of observed carious teeth giving the total estimated number of teeth with carious lesions. The estimate is then divided by the total number of original teeth to give a frequency (Lukacs, 1995).

Corrected Caries Rate (Lukacs, 1995):

1) Estimated number of teeth lost due to caries

= [# of teeth lost antemortem] x [proportion of teeth with pulp exposure due to caries]

2) Total estimated number of teeth with caries

= [estimated number of teeth lost due to caries] + [number of carious teeth observed]

3) Total number of original teeth

= [number of teeth observed] + [number of teeth lost antemortem]

4) Corrected caries rate

= [total estimated number of teeth with caries] ÷ [total number of original teeth]

Figure 7.3: Caries correction factor. Based on Luckacs (1995).

Calculus

All fully erupted teeth present in the dentition were scored for calculus. Each tooth received a score for the buccal/labial (cheek/lip), lingual (tongue) and interproximal (between teeth) surfaces. Surfaces missing or damaged due to fracture, caries, etc. were not scored. The amount of calculus was scored as absent (0), small (1), moderate (2) or large (3) (Buikstra and Ubelaker, 1994). A small amount is defined as a narrow, thin (<2mm) band covering less than 1/3 of the tooth surface. A moderate amount consists of a thin band covering more than 1/3, but less than 2/3 of the tooth surface. A large amount covers more than 2/3 of the tooth surface or may be a continuous thick (>2mm) band around the cervical portion of the tooth (Buikstra and Ubelaker, 1994; Nguyen, 1982).

Running separate tests for each tooth surface (66 individual tests) is not particularly meaningful, and calculus indices are used here and adapted from the Simplified Calculus Index (CI-S) that is obtained by dividing the total of the calculus scores by the number of surfaces scored (Nguyen, 1982). The CI-S, used by dental clinicians, provides a single score for an entire set of teeth. Because some crania retained more teeth in certain quadrants of the mouth than others, this study uses a modified CI-S to obtain four indices for: (1) the upper posterior dentition (CI-UP); (2) the lower posterior dentition (CI-LP); (3) the upper anterior dentition (CI-UA); and (4) the lower anterior dentition (CI-LA) (Greene et al., 2005).

Minimally, each surface must be scorable on at least one antimere to obtain the index; in these and other samples the right and left sides do not show significant variation in amount of calculus ($p=0.549$). The score of any given tooth in a CI area tends to reflect the composite score for that quadrant (Greene et al., 2005). Use of indices rather than use of a single representative tooth: increases sample size in cases where the hypothetical representative tooth is missing or damaged and, decreases bias in cases where that tooth may show unusual characteristics. For example, in instances of hypodontia or hyperdontia, it may appear that less or more of the tooth is covered than by the same amount of calculus on surrounding teeth.

To obtain the CI-UP, three scores per tooth for the maxillary right and left molars and premolars are summed and divided by the total number of surfaces scored (three surfaces x 10 teeth = 30 surfaces scored when all molars and premolars are present and undamaged). This method is then repeated for the remaining calculus indices to give each individual four composite calculus scores (Greene et al., 2005).

Abscess

All maxilla and mandibles were examined for abscess. One difficulty is that there are no standards (or even mention of such in the literature) to account for healed abscess or severity of abscess. Such standards are not established here, rather location of the abscess was recorded including the tooth involved and whether the abscess occurred on the buccal/labial or lingual aspect of the jaw.

Periodontal Disease

All maxilla and mandibles were examined for periodontal disease. Root exposure alone is not enough to classify bone loss as due to periodontal disease. Periodontitis was only scored as present if the bone crest of the alveolar margins revealed porous cancellous spaces and altered morphology (Clarke et al., 1986). Location of periodontal bone loss was recorded as to each tooth involved; maxillary left first molar, mandibular right second incisor, etc. Type of bone loss was scored as horizontal or vertical. In the case of horizontal bone loss, the root exposure was measured (Costa, 1982). Vertical bone loss was scored as: (1) a one-surfaced crater, involving only one side of a tooth; (2) a two-surfaced crater, involving the inter-proximal wall between neighboring teeth; (3) a trench, involving two or three sides; or (4) a moat, involving all sides of a tooth (Karn et al., 1970).

Linear Enamel Hypoplasia

All teeth with fully formed crowns, except third molars, were scored for hypoplastic enamel defects. Third molars were excluded because they display a greater amount of normal variation (Goodman et al., 1984a; Goodman and Armelagos, 1985b). If enamel was missing from the labial side of an anterior tooth or the buccal side of a molar, that tooth was excluded. Hypoplastic defects most often appear on the buccal or labial side of a tooth, possibly because the greater relief on the lingual side makes the defect more difficult to discern (Goodman and Armelagos, 1985b). In order to remain conservative and not score normal variation in perikymata as hypoplastic enamel defects, only defects visible to the naked eye were scored. For each defect, the type and severity of the defect was recorded as well as the location on the crown.

Type of defect was recorded as a groove defect or a pit defect. Some scoring systems recommend a greater number of classifications (e.g. Buikstra and Ubelaker, 1994), however, these two broad categories can be distilled from the more complicated systems as a number of the categories indicated by Buikstra and Ubelaker (1994) are extremely rare. Grooves and pits were scored separately because their etiologies may differ (Pindborg, 1970).

Defect location was measured as the distance from the cemento-enamel junction (Buikstra and Ubelaker, 1994; Goodman and Rose, 1990). This measurement was placed into a tooth specific regression formula in order to determine the age at which the defect occurred (Goodman and Rose, 1990). However, to increase sample sizes, age of occurrence of the defect was categorized as less than four years of age or four years of age and older.

Severity of the defect was determined via the hypoplastic area method (Ensor and Irish, 1995). Only polar teeth (UI1, LI2, UC, LC, UP1, LP1, UM1, and LM1) were used to determine severity. The hypoplastic area method enables categorization of the lesions as acute or chronic. Acute lesions are defined as a pit or a band of 0.5 mm or less. Larger lesions are defined as chronic. Acute lesions are given a score of 0.10. Width of the lesion in millimeters is the score for chronic lesions. The score for chronic lesions is divided by 2/3-crown height. Thus, the hypoplastic area method cannot be used for heavily worn teeth. Scores for acute lesions are summed. The two values, for acute and chronic are then added to obtain the Tooth Hypoplastic Area (THA). In order to increase sample size, missing data were substituted with within-sample means (Ensor and Irish, 1995:511). The THA is used to determine a single value for each individual called the Individual Hypoplastic Area (IHA). The IHA is the mean of the THA for the eight polar teeth (Ensor and Irish, 1995).

Antemortem Tooth Loss

All maxilla and mandibles were scored for antemortem tooth loss (AMTL). AMTL was scored by identifying which tooth was missing as well as the degree of resulting bone remodeling. Degree of bone remodeling helps to distinguish AMTL from post-mortem loss or congenitally missing teeth. Bone remodeling was recorded as: (1) alveolus beginning to resorb; (2) alveolus completely obliterated but much bone still present; or (3) significant bone loss.

Macrowear

Attrition was recorded for all fully erupted first and second molars (Pechenkina, 2002). Molars that appeared to have wear patterns that resulted from task-related tooth use as described by Milner and Larsen (1991) and Lukas and Pastor (1988), were excluded. Although macrowear on anterior teeth may have a different etiology than that on posterior teeth, anterior teeth were excluded due to small sample sizes. Molars were scored according to Scott (1979a). With this method, molars are visually divided into four quadrants. Each quadrant is scored separately on a scale of 1 to 10. A score of 1 means wear facets are invisible or very small. A score of 10 means there is no enamel left on any part of the quadrant. The scores for each quadrant are added to give the score for the tooth, which thus ranges from four to 40.

Microwear

All suitable mandibular left second molars (Gordon, 1982a; Harmon and Rose, 1988; Kay, 1987; Schmidt, 1998) were examined for microwear. A suitable molar contained a use-wear surface without post-mortem damage or casting artifacts (Teaford, 1988b). In order to keep sample sizes high, the right M2 was used if the mandibular left M2 was not present. In a few cases maxillary second molars were used. Researchers have not found significant differences in microwear between maxillary and mandibular teeth (Teaford, 1991). In fact some researchers (Grine, 1987; Grine and Kay, 1988; Rafferty et al., 2002; Teaford and Runestad, 1992) primarily use maxillary second molars. For juveniles, deciduous second or permanent first molars were used. While Gordon (1984b) found the percentage of pits, mean scratch length and pit diameter differed among the molars of chimpanzees, she states that the differences are a result of the functional anatomy of the primate jaw. Thus, for comparisons between juveniles and adults the selected teeth should be functioning in the same way.

In order to view an object under the scanning electron microscope (SEM), that object must first be covered with metal. Using casts of teeth maintains the teeth for future research. Molds of all teeth examined were made using a low consistency polyvinylsiloxane impression material (Schmidt, 1999; Teaford and Runestad, 1992; Teaford et al., 1996; Ungar, 1996) that reproduces features with resolutions to a fraction of a micron (Benyon, 1987). Before making the molds, teeth were washed with a 95% solution of ethyl alcohol (EtOH) and a cotton swab in order to remove any surface contamination. Molds were allowed to de-gas for at least 24 hours before making casts (Schmidt, 1999).

Casts of each tooth were made from the molds using a 4:1 super-hard epoxy resin (Grine and Kay, 1988; Kay, 1987; Schmidt, 1999; Teaford, 1984; Teaford and Runestad, 1992; Teaford et al., 1996). Filled molds were centrifuged in a VWR scientific GT-2 centrifuge for 15 to 30 seconds in order to force the resin deeply into the relief of the molds and remove any air bubbles from the resin (Schmidt, 1999). Each cast was given a unique number by an outside party so that the site, sex and age of each tooth were unknown until analysis of all micrographs was complete. For viewing in the SEM, tooth casts were mounted on an aluminum stub and sputter-coated with approximately 200 angstroms of gold-palladium (AuPd) in an International Scientific Instrument PS-2 coating unit. The thickness of gold-palladium coating is determined by the following equation:

$$d = MA \times kV \times t \times 5$$

where MA is Milliamps, kV is kilo-voltage, t is time and 5 is a constant. In order to achieve 200 angstroms the following numbers are placed into the equation:

$$d = 18MA \times 1.3kV \times 1.7 \text{ (minutes)} \times 5.$$

Table 7.3 provides detailed steps for creating casts, molds and images.

Table 7.3: Steps to obtain microwear image.

	Create Mold of tooth	**Create Cast of tooth**	**Prepare cast for SEM**	**Obtain SEM Image**
Step 1	Determine which individuals have useable 2nd molars	Clean mold with EtOH	Separate protoconid from cast	Place cast in vacuum chamber
Step 2	Clean those molars which EtOH and a cotton swab	Mix epoxy resin base and catalyst 4:1 by weight	Discard remainder of cast, keep cast of protoconid	Depressurize vacuum chamber
Step 3	Apply Polyvinylsiloxane to tooth	Add epoxy resin to mold	Mount cast on aluminum stub	Set working distance at 28mm
Step 4	Allow to set	Centrifuge mold for 30 seconds	Sputter coat with 200Ag of AuPd	Set beam current
Step 5	Remove mold	Allow epoxy resin to set		Locate Phase II wear facet on screen
Step 6	Allow mold to degas for 24 hours	Remove cast from mold		Zoom to 500-x mag.

Micrographs were taken of the Phase II wear facet (as defined by Kay, 1977) on each protoconid (see Figure 7.4), or protocone in the case of maxillary molars, approximately halfway between the cusp tip and the central basin (Gordon, 1984a; Ungar, 1996). However, the wear facets are not always evident on molars that are worn flat. In these instances micrographs were collected from the buccal half of the central basin of mandibular molars and the lingual half of the central basin of maxillary molars (Rafferty et al., 2002). The mesial side of the tooth was positioned at the top of the screen in order to control for orientation.

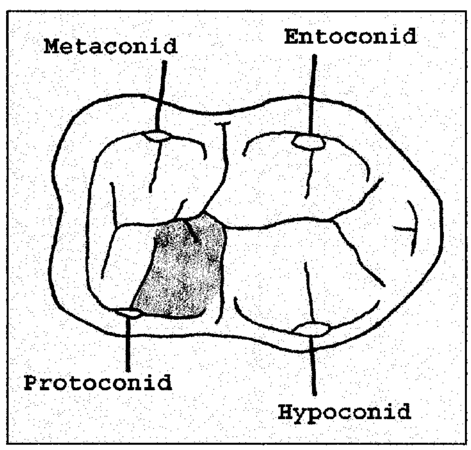

Figure 7.4: Phase II wear facet. Adapted from Kay (1977).

Images were obtained on an International Scientific Instruments (ISI-40) SEM at 500x magnification in the secondary emissions mode (Teaford and Walker, 1984; Teaford, 1984, 1991; 1994; Teaford et al., 1996). A magnification of 500x yields an image of an area approximately $0.02m^2$. Different researchers use a variety of magnifications for microwear studies. Some prefer a low magnification (100x – 200x), while others prefer a high magnification (1500x) and still others prefer a magnification in between (500x). A low magnification allows observation of a greater area, but does not have the resolution of higher magnifications A high magnification allows for greater accuracy, but a smaller area of the tooth may be studied (Gordon, 1988b). A medium magnification, such as 500x used in this study, allows for a larger area than 1500x but with greater resolution than 200x (Fredericksen, 2000). All images were obtained at a working distance of 25-28 mm. In order to reduce foreshortening of the features, wear facets were placed perpendicular (or as close as possible) to the image collector (Gordon, 1988a; Kay, 1987).

Images of the Phase II wear facets were transferred directly from the SEM to computer via an Iridium Digital Imaging System. A semi-automated computer program, *Microwear* 4.0 developed by Peter Ungar (2000), was used to analyze digital images of the tooth surface (see Figure 7.5).

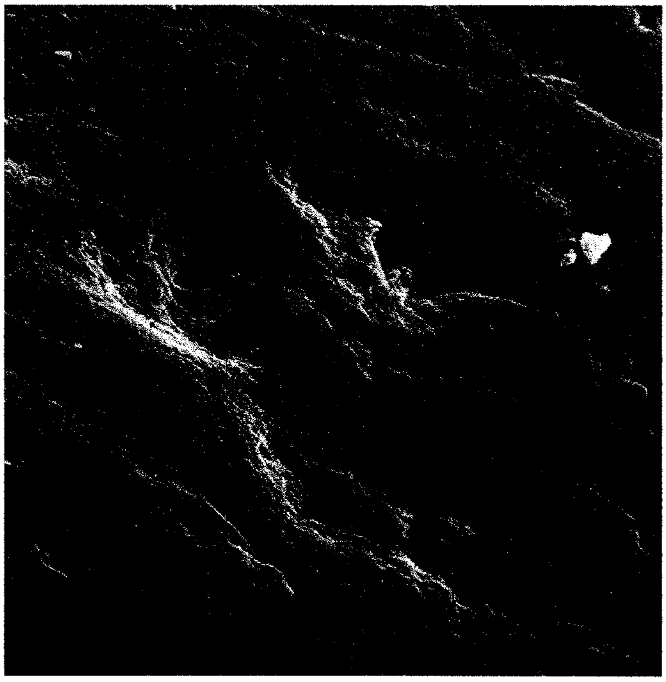

Figure 7.5: Microwear analysis. Lines mark each feature, which are measured by the computer. Image area is 0.25 mm^2.

Statistical Methods

All statistical analyses were completed using the computer software Statistical Package for the Social Sciences (SPSS) 12.0. SPSS is a comprehensive software package that uses data from almost any type of file to generate tables, charts and plots of distributions and trends, descriptive statistics and complex statistical analyses (Norusis, 1999).

Analysis of Variance

Analysis of variance (ANOVA) may be used for two purposes: (1) to estimate and test hypotheses about population variances and (2) to estimate and test hypotheses about population means. However, it should be noted that conclusions regarding the means depend on the magnitudes of the observed variances. One benefit of ANOVA is that it controls for several independent variables individually, as well as interactions between variables (Daniel, 1999).

This study uses ANOVA to analyze the number of carious lesions per tooth as well as per mouth, the number of abscesses per mouth, the number of individuals with periodontal disease (Ibrahim, 1987), severity of hypoplastic defects (Ensor and Irish, 1995), the degree of macrowear per tooth, and the frequency and length of microwear features (Schmidt, 1998). In this study, the independent variables are age, sex and site. Interactions between independent variables for this study are age*sex, age*site, sex*site and age*sex*site.

Two-way ANOVA is used for intra-site comparisons, while three-way ANOVA is used for inter-site comparisons. In a two-way ANOVA data are divided into two treatments: for this study the treatments are age and sex. In three-way ANOVA, data are divided into three treatments: for this study those treatments are age, sex, and site (Madrigal, 1998).

Analysis of Variance only ascertains if a difference exists. ANOVA does not reveal where the variance lies (e.g., between age groups four and five, five and six, or four and six). In order to determine where variance lies, a post-hoc test, also known as a test of homogeneity, must be completed. While there are numerous post-hoc tests, this study uses the least significant difference (LSD). LSD post-hoc comparisons use *t* tests to compare all pair-wise means (Norusis, 1999).

Mann-Whitney *U*

Mann-Whitney *U* is a non-parametric test that may replace an independent samples *t*-test when the latter is not appropriate. Unlike the parametric *t*-test, non-parametric tests do not make assumptions about the distribution of the population from which samples were collected. Thus, non-parametric tests can be applied to non-normal data, which is important when sample sizes are small. Another advantage of non-parametric tests is that they only need the data to be ranked and do not require exact measurements (Madrigal, 1998), as is the case for the present study.

The Mann-Whitney *U* test makes only two assumptions. One is that the level of measurement is continuous between samples. That is, if sample one is recorded as ranked data, sample two must also be recorded as ranked data. Assumption two is that samples have been independently drawn from their populations. The null hypothesis of the Mann-Whitney *U* test is that the population from which the samples are obtained is the same (Madrigal, 1998). Mann-Whitney *U* is used here to analyze the severity of carious lesions, amount of calculus, and type of periodontal bone loss (Ibrahim, 1987).

Chi-Square

The chi-square (χ^2) distribution is a non-parametric test. Chi-square is the most frequently used statistical test when analyzing count or frequency data (Daniel, 1999). The purpose of chi-square is to determine if the observed frequencies differ significantly from frequencies proposed by a null hypothesis. There are two ways to generate expected frequencies. One way is when expected frequencies are pre-determined, such as gene frequencies (Madrigal, 1998). The method used in this study is to estimate what the cell frequencies should be if the null hypothesis is true. In this case, expected frequencies are obtained by multiplying the row total by the column total and dividing by the grand total (Daniel, 1999). The null hypothesis states that the two variables are independent (Madrigal, 1998).

Chi-Square was used to analyze the number of individuals with carious lesions, abscess and periodontal disease, the location of carious lesions on each tooth and location of abscess, as well as the frequency, type (Blakey et al., 1990), and age of occurrence (Goodman, 1984) of linear enamel hypoplasia among different groups. When the sample size fell below five, the Yates correction factor was applied regardless of table size. SPSS does not apply the Yates correction factor to larger than 2 x 2 tables. Thus, all chi-square tests were computed manually and the values were compared to a table in Madrigal (1998). Because the results were compared to a published table, exact p-values were not determined.

Carious Lesions

Because carious lesions are the most frequently studied dental pathology, a number of comparisons are often made. Caries scoring included count data, ranked data, and continuous variables. Count data was tested using chi-square including: the number of individuals with at least one lesion (individual count), number of teeth with at least one lesion (tooth count), and the location of recorded lesions. Mann-Whitney *U* was used to compare the severity of the lesions. Scores of zero, or no lesions, were not considered in tests of severity. Of those individuals affected by carious lesions, the number of lesions per mouth was compared using two-way ANOVA within sites. Three-way ANOVA was used to compare the number of lesion per mouth between sites. This variable meets the assumptions of ANOVA in that: (1) the inclusion of one individual did not influence which other individuals were included; and (2) there is a normal distribution of the number of lesions. Intra-site tests controlled for two independent variables of age and sex as well as their interaction. Inter-site tests controlled for three independent variables of age, sex, and site as well as their interactions.

Carious lesions can affect, or may be affected by, other dental pathologies. Thus, a Pearson's correlation coefficient was determined between carious lesions severity and number of abscesses per mouth, as well as between calculus severity and the number of carious lesions per mouth.

Calculus

Calculus amount was recorded on a ranked scale (0 to 3) for three surfaces of each tooth. Although the four indices may give the illusion of ratio level data, it is still most appropriate to use non-parametric tests as. Non-parametric tests, which are more conservative, are used because the data were ranked before being transformed into indices and the indices themselves still can only range from 0 to 3. Calculus severity was compared using Mann-Whitney *U* tests on each of the four calculus indices.

Abscess

The number of individuals with at least one abscess was compared using the chi-square test for goodness-of-fit. Of those individuals affected by abscess, the number of abscesses per mouth was compared using ANOVA. This variable meets the assumptions of ANOVA in that (1) the inclusion of one individual did not influence which other individuals were included, and (2) there is a normal distribution of the number of lesions. Within-site tests controlled for two independent variables of age and sex as well as their interaction. Between-site tests controlled for three independent variables of age, sex, and site as well as their interactions.

Periodontal Disease

The number of individuals affected by periodontal disease were compared using the chi-square test for goodness-of-fit. Of individuals affected, the type of periodontal bone loss experienced was compared using the chi-square test for independence. Of those individuals experiencing horizontal bone loss, amount of root exposure was compared using ANOVA. This variable meets the assumptions of ANOVA in that (1) inclusion of one individual did not influence which other individuals were included, and (2) there is a normal distribution of the number of lesions. Within-site tests controlled for two independent variables of age and sex as well as their interaction. Between-site tests controlled for three independent variables of age, sex, and site as well as their interactions. Among individuals experiencing vertical bone loss, the surfaces involved were scored as ranked data. These scores were averaged and compared using the Mann-Whitney *U* test.

Antemortem Tooth Loss

The number of individuals experiencing any antemortem tooth loss (AMTL) was compared using the chi-square test for goodness-of-fit. For individuals affected by AMTL, the number of teeth lost per mouth was compared using ANOVA. This variable meets the assumptions of ANOVA in that (1) inclusion of one individual did not influence which other individuals were included, and (2) there is a normal distribution of the number of teeth lost. Intra-site tests controlled for two independent variables of age and sex as well as their interaction. Inter-site tests controlled for three independent variables of age, sex, and site as well as their interactions.

Linear Enamel Hypoplasia

The number of individuals with at least one hypoplastic defect, the type of hypoplastic defect, and the age at which the defect occurred were compared using the chi-square test for goodness-of-fit. The Tooth Hypoplastic Area (THA) was compared using ANOVA. This variable meets the assumptions of ANOVA in that (1) inclusion of one individual did not influence which other individuals were included, and (2) there is a normal distribution of the number of defects. Intra-site tests controlled for two independent variables of age and sex as well as their interaction. Inter-site tests controlled for three independent variables of age, sex, and site as well as their interactions.

Macrowear

Statistical analysis of macrowear concentrates on the first and second molars (Edwards, 1984; Schmidt, 1998). Anterior teeth are excluded because they are more likely to exhibit non-masticatory wear (Hillson, 1996), which, while useful, is not the focus of this study. Highly variable eruption times and agenesis of third molars (Scott, 1979b) may affect the severity of attrition; therefore third molars are not used.

Mean wear scores for the first and second maxillary and mandibular molars were computed for each individual. Wear scores for the right and left molars were averaged to give the mean wear score for maxillary and mandibular M1 and maxillary and mandibular M2. Other methods would be to use either the left or right side exclusively, or to choose the side with the greatest wear score. However, most individuals chew on one side preferentially (Hiiemae, 1978). Use of a mean score eliminates bias due to sidedness. Ibrahim (1987) suggests that the maxillary and mandibular dentitions be considered separately due to differences in wear exhibited by the groups in his study. The samples used for this study also exhibit differences between macrowear of the maxillary and mandibular molars. Wear scores were compared using ANOVA. This variable meets the assumptions of ANOVA in that (1) inclusion of one individual did not influence which other individuals were included, and (2) there is a normal distribution of the amount of wear. Intra-site tests controlled for two independent variables of age and sex as well as their interaction. Inter-site tests controlled for three independent variables of age, sex, and site as well as their interactions.

Microwear

The presence of polish was compared using chi-square test. Total number of features, number of enamel prisms, percentage of pits, scratch width and pit breadth were compared using ANOVA. Because individual features cannot be treated as independent events, statistical analysis of scratch width, and pit breadth is conducted on the mean values for each individual (Teaford and Runestad, 1992). All data for each cemetery were tested for normality using the Kolmogorov-Smirnov test with Lilliefor's correction (Teaford et al., 1996). To meet the assumptions of ANOVA, some of the data had to be transformed. Feature tally was square root transformed after the outliers of >70 features per image had been removed. All of the three outliers were of unknown sex and would have been excluded from most tests regardless. Striation width was log-transformed after the outliers of greater than 6.0 μ had been removed. Pit width was rank transformed and the number of prisms (of those with polish) was log-transformed. Rank transformation makes the data distribution free, allowing it to conform to the assumptions of ANOVA. Intra-site tests controlled for the two independent variables of age and sex as well as their interaction. Inter-site tests controlled for three independent variables of age, sex, and site as well as their interactions.

CHAPTER EIGHT

RESULTS

In the following chapter the statistical analysis of each dietary indicator between males and females of each adult age group at Hierakonpolis, between males and females of each adult age group at Naqada, and between Hierakonpolis and Naqada for each age and sex group where possible is described. Because most indicators proved to be age dependent, inter-age comparisons of males and females for the two sites were not made. For inter-site comparisons, age groups were combined when necessary due to small sample sizes or expected frequencies of less than one for certain age groups. Comparisons of all males and females include individuals of undetermined age. Asterisks (*) beside the p values denote significant differences at the $\alpha = 0.05$ level.

Within Site Comparisons: Hierakonpolis

Carious Lesions

Sixty males with a total of 1128 teeth and 76 females with a total of 1476 teeth were scored for carious lesions. One individual in the 6-12 year age category expressed a non-occlusal lesion on a deciduous tooth. One individual in the 12-18 year age category expressed an occlusal lesion on a permanent tooth. There were no other carious lesions among juveniles.

There were no significant differences in the number of males and females with at least one carious lesion in any of the age groups. Table 8.1 shows the chi-square results for individual count frequencies of carious lesions. The highest percentage of males with at least one carious lesion occurred in the 35-50 year age category, while the highest percentage of females occurred in the 18-35 year age category; however, differences between the sexes are generally small. The only seemingly large difference occurs in the percentage of males (40.0%) and females (16.7%) in the 50+ year age category, although the difference is not significant due to the small sample size in that age category.

Table 8.1: Chi-square results for occurrence of carious lesions (individual count).

AGE	MALES		P	FEMALES	
	n	%		N	%
All	61	37.7%	>0.80	76	35.5%
18-35	40	35.0%	>0.50	54	38.9%
35-50	16	43.8%	>0.30	16	31.2%
50+	5	40.0%	>0.80	6	16.7%

After applying Lukacs' Caries Correction Factor (Lukacs, 1995), the number of carious teeth among males and females were compared. Carious lesions affected a very low proportion (less than six percent) of teeth from Hierakonpolis. Both males and females showed the greatest percentage of carious teeth in the 35-50 year age category. There are no significant differences in the number of teeth with carious lesions between the sexes in any of the age categories. Table 8.2 shows the chi-square results for corrected tooth count frequencies of carious lesions.

Table 8.2: Chi-square results for occurrence of carious lesions (corrected tooth count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	1128	3.9%	>0.20	1476	3.1%
18-35	767	3.4%	>0.70	1034	3.1%
35-50	272	5.5%	>0.30	311	4.0%
50+	89	3.4%	>0.50	131	1.5%

Overall, males had an average of 0.75 carious teeth per individual, whereas females had an average of 0.77 carious lesions per individual. Of those individuals with at least one carious lesion, males had an average of 2.2 lesions, while females had an average of 1.8 lesions per mouth. Analysis of Variance (ANOVA) does not show any significant differences for number of lesions per mouth between the sexes regardless of age. Table 8.3 illustrates the ANOVA results for number of carious lesions per mouth. Pearson's Product Moment Correlation coefficient shows that the number of carious lesions per mouth is positively correlated ($r = 0.318$) to calculus severity and is a true correlation ($p = 0.000$). When the p value for a correlation shows significance, the r value is a true representation of the relationship between the variables, or is said to be a true correlation (Daniel, 1999).

Table 8.3: Two-way ANOVA for number of lesions per mouth (among individuals with at least one lesion).

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	15.048	7	2.150	1.173	0.337
Sex	1.178	2	0.589	0.321	0.727
Age (adults only)	11.458	3	3.819	2.084	0.200
Sex * Age	1.446	2	0.723	0.395	0.676
Error	84.286	46	1.832		
Total	292.000	54			
Corrected Total	99.333	53			

The sources of variation for the two-way ANOVA table are listed along the left column. The 'Corrected Model' is the amount of variability that can be explained by the main effects. The main effects are 'Sex' and 'Age', the interaction of the main effects is 'Sex*Age'. 'Error' estimates of how much the observations vary within a group. 'Total' is all groups combined.' Corrected Total' shows how much the observed values differ from the mean in all cases combined (Norusis, 1999).

In the two-way ANOVA table, the 'Sum of Squares' is a measure of variation. Sum of squares is obtained by subtracting the mean for a group from each value in that group. The differences are then squared and summed. 'Type III Sum of Squares' is most commonly used because it is invariant with respect to the cell frequencies. The 'df', degrees of freedom, is equal to the number of cases minus one (Norusis, 1999).

The 'Mean Square' is a measure of variance obtained by dividing the sum of squares by the degrees of freedom. The mean square of the 'Error' is an estimation of the population variance. The mean square of 'Age', shows how much the sample means of the age groups vary. The mean square of 'Sex', shows how much the sample means of the sex categories vary. The mean square of 'Sex*Age' shows the variance of all sex *and* age means (Norusis, 1999).

The 'F' ratio is computed by dividing the main effect and interaction mean squares by the error mean square. The 'F' ratio is compared to a table value, dependent upon the degrees of freedom, to determine significance, which is represented here by 'P' (Norusis, 1999).

Carious lesion location was scored as occlusal or non-occlusal. Lesions that were too large to assign a surface of origin were not considered, thus excluding most individuals in the 50+ year age category. For the Hierakonpolis sample, the majority of the lesions were occlusal (58.4%). The 35-50 year age category expressed the lowest percentage of occlusal lesions for both males and females. There were no significant differences between males and females in the 18-35 or 35-50 year age categories. Table 8.4 shows the chi-square results for carious lesions location. Males and females over 50 years of age could not be compared because males had only lesions that could not be assigned a location (Norusis, 1999).

Table 8.4: Chi-square results for carious lesion location

AGE	**MALES**		**P**	**FEMALES**	
	n (lesions)	% occlusal		n (lesions)	% occlusal
All	36	61.1%	>0.50	41	56.1%
18-35	22	77.3%	>0.10	30	60.0%
35-50	14	35.7%	>0.70	9	44.4%
50+	0	NA	NA	2	50.0%

As stated in Chapter Seven, caries severity was assigned as (1) pin-prick to 1mm, (2) 1mm to 1/4 of the tooth crown, (3) greater than 1/4 of the tooth crown, or (4) complete or near complete destruction of the tooth. Most of the carious lesions of both males and females tended to be between 1 mm and 1/4 of the tooth crown, with the exception of males in the 50+ year age category where 66.7% of the teeth with caries were completely destroyed. There were no significant differences in the severity of carious lesions between the sexes in any of the age categories. Table 8.5 shows the Mann-Whitney *U* results for severity of carious lesions.

Table 8.5: Mann-Whitney *U* results for caries severity

AGE	MALES				P	FEMALES			
	n	% 1	% 2	% 3	P	n	% 1	% 2	% 3
All	46	28.3%	54.3%	4.3%	0.282	46	34.8%	56.5%	2.2%
18-35	26	34.6%	50.0%	3.8%	0.529	32	37.5%	56.3%	3.1%
35-50	15	20.0%	73.3%	6.7%	0.815	12	25.0%	58.3%	0%
50+	3	0%	33.3%	0%	0.128	2	50.0%	50.0%	0%

Calculus

Individuals at Hierakonpolis had very little calculus. Calculus scores were recorded on 65 males and 80 females. Most tooth surfaces exhibited scores of either 0 (absent) or 1 (small amount) for both males and females regardless of age. Males had a higher index than females in the 18-35 and 35-50 year age categories for all four calculus indices; however, females had a higher calculus index than males in the 50+ year age categories in all indices. Tables 8.6 and 8.7 show the means of the calculus indices. Means are used only for visual comparison, not for statistical analysis. Males had a similar amount of calculus in each age category with the exception of the maxillary posterior teeth, where the 50+ year age category appears much lower. Females over 50 years appear to have much more calculus than younger groups for all teeth.

Calculus indices between males and females did differ significantly for the maxillary teeth (see Table 8.6) but not for mandibular teeth (see Table 8.7). Males in the 18-35 year age category had significantly more calculus on the maxillary anterior teeth than females. In the 35-50 year age category, males had significantly more calculus on the maxillary posterior teeth than females. Females in the 50+ year age category had significantly more calculus than males on the maxillary posterior teeth.

Table 8.6: Mann-Whitney *U* results for amount of calculus on maxillary teeth.

AGE	Anterior Teeth			Posterior Teeth		
	Male mean	**P**	**Female mean**	**Male mean**	**P**	**Female mean**
All	0.407	0.075	0.285	0.481	0.469	0.421
18-35	0.460	0.032*	0.287	0.462	0.661	0.422
35-50	0.453	0.291	0.212	0.705	0.038*	0.361
50+	0.307	0.310	0.533	0.168	0.010*	0.708

*denotes statistically significant differences at the 0.05 level.

Table 8.7: Mann-Whitney *U* results for amount of calculus on mandibular teeth.

AGE	Anterior Teeth			Posterior Teeth		
	Male mean	**P**	**Female mean**	**Male mean**	**P**	**Female mean**
All	0.640	0.586	0.617	0.565	0.250	0.488
18-35	0.654	0.295	0.576	0.582	0.132	0.474
35-50	0.626	0.880	0.618	0.647	0.235	0.444
50+	0.675	0.548	0.861	0.538	0.310	0.835

Abscess

Abscess expression was very low for the Hierakonpolis sample with only nine males and five females having any abscess. Despite the low number of affected individuals, there is a trend for the percentage of individuals with at least one abscess to increase with age for both males and females. The only exception is that no females in the 35-50 year age category expressed an abscess, while two out of 52 females in the 18-35 year age category and three out of six females in the 50+ year age category expressed abscess. Pearson's Product Moment Correlation Coefficient shows that abscesses are positively correlated with caries severity (r = 0.303) and that the correlation is true (p = 0.000).

A greater proportion of males than females had at least one abscess in each age category, however the differences were not statistically significant. Table 8.8 shows the chi-square results for presence of abscess. The chi-squared test could not be run for the 35-50 year age category, because the females had expected frequencies of less than one. There are no individuals with abscesses in any juvenile age category.

Table 8.8: Chi-square results for abscess presence (individual count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	63	12.7%	>0.20	74	6.8
18-35	42	7.1%	>0.70	52	3.8%
35-50	16	12.5%	NA	16	0%
50+	5	60.0%	>0.80	6	50.0%

The number of abscesses per individual among the Hierakonpolis sample was fairly small. Of the 14 individuals with abscesses, six males and three females had only one abscess. Both males and females had only one individual with two abscesses. Two males and one female had three or more abscesses. Of those individuals affected by abscess, males had an average of 1.9 lesions per mouth, while females had an average of 1.6 per mouth. Males had a greater number of abscesses per mouth than females in each of the age categories, however those differences were not statistically significant. Table 8.9 shows the ANOVA results for number of abscesses per individual.

Table 8.9 Two-way ANOVA results for number of abscesses per mouth.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	11.767	6	1.961	1.034	0.468
Sex	3.566	2	1.783	1.576	0.430
Age (adults only)	8.963	3	2.988	0.941	0.269
Sex *Age	1.185	1	1.185	0.625	0.452
Error	15.167	8	1.896		
Total	72.000	15			
Corrected Total	26.933	14			

Periodontal Disease

The incidence of periodontal disease was very low: only six males and seven females from the sample expressed a bony lesion. Both males and females saw an increase in the amount of periodontal disease with age. There are no significant differences in the number of individuals with periodontal disease between males and females in any of the age categories. Table 8.10 shows the chi-square results for periodontal disease presence. No juveniles expressed periodontal disease.

Table 8.10: Chi-square results for occurrence of periodontal disease (individual count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	67	9.0%	>0.80	76	7.9%
18-35	42	4.8%	>0.70	52	1.9%
35-50	16	12.5%	>0.80	16	18.8%
50+	5	40.0%	>0.50	6	60.0%

Type I periodontal disease refers to horizontal bone loss or generalized periodontal diseases, while Type II refers to vertical or pockets of bone loss. The numbers of males (three) and females (four) with vertical bone loss are very similar as are the number of males (three) and females (five) with horizontal bone loss. Among males, three teeth exhibited Type II periodontal disease and eight teeth showed Type I. Among females, four teeth showed Type II, while eight teeth showed Type I. Three females experienced both Type I and Type II periodontal disease. The horizontal and vertical bone loss occurred in separate quadrants in all three individuals. There are too few individuals affected by periodontal disease to compare type of bone loss for each age category, therefore the age groups were combined. Males and females do not differ significantly by type of periodontal disease. Table 8.11 shows the chi-square results for type of periodontal disease.

Table 8.11: Chi-square results for type of periodontal disease (tooth count).

AGE	**MALES**			**P**	**FEMALES**		
	n lesions	% Type I	% Type II		n lesions	% Type I	% Type II
Combined due to sample Size	11	72.8%	27.2%	>0.70	13	61.5%	38.5%

The amount of root exposure was measured for 17 teeth with horizontal bone loss. ANOVA shows that amount of root exposure does not differ significantly by age ($p=0.999$). Of those with horizontal bone loss, males had significantly greater root exposure than females. Table 8.12 shows the ANOVA results for amount of root exposure in millimeters. Males had a mean root exposure of 5.68 mm, while females had a mean root exposure of only 3.33 mm.

Table 8.12: Two-way ANOVA results for amount of root exposure.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	28.644	5	5.729	3.504	0.039
Sex	16.329	1	1.143	9.987	0.009*
Age (adults only)	2.286	2	16.329	0.001	0.999
Sex *Age	3.652	1	3.652	2.233	0.163
Error	17.985	11	1.635		
Total	374.870	17			
Corrected Total	46.629	16			

*denotes statistically significant differences at the 0.05 level.

Teeth were scored for surface of vertical bone loss as (1) a one-surfaced crater, (2) a two-surfaced crater (3) a trench, or (4) a moat. Of the three males with vertical bone loss, one experienced a one-surfaced crater, one experienced a two-surfaced crater and one experienced a trench. The majority of females experienced a one-surfaced crater with no two-surfaced craters or trenches. There are too few individuals affected by periodontal disease to compare surfaces of bone loss for each age category, therefore the age groups were combined. The differences between males and females were not statistically significant. Table 8.13 shows the Mann-Whitney *U* results for the surfaces affected by Type II periodontal disease.

Table 8.13: Mann-Whitney *U* results for surface of vertical bone loss (tooth count).

AGE	**MALES**				**P**	**FEMALES**			
	n	% 1	% 2	% 3		n	% 1	% 2	% 3
Combined due to sample Size	3	33.3%	33.3%	33.3%	0.283	6	83.3%	0%	0%

Antemortem Tooth Loss

Very few individuals experienced any antemortem tooth loss (AMTL). The percentage of individuals with AMTL tends to increase with age; however, there are a slightly higher proportion of males with AMTL in the 35-50 year (62.5%) age category than in the 50+ years (60.0%). In the 18-35 year age category, females have slightly more individuals with AMTL than males, but males are higher than females in the 35-50 and 50+ year age categories. None of these differences are statistically significant. Table 8.14 shows the chi-square results for antemortem tooth loss. No juveniles experienced antemortem tooth loss that was unrelated to the natural shedding of deciduous teeth.

Table 8.14: Chi-square results for occurrence of AMTL (individual count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	65	18.5%	>0.20	80	12.5%
18-35	44	6.8%	>0.70	56	7.1%
35-50	16	62.5%	>0.30	18	22.2%
50+	5	60.0%	>0.80	6	33.3%

Of the twelve males who experienced AMTL, only five lost more than one tooth. Within the 35-50 year age category, one lost two teeth, one lost three teeth, and one lost four teeth. Two males in the 50+ year age category lost six teeth. Of the ten females who experienced AMTL, four lost only one tooth, five lost two teeth, and one in the 35-50 year age category lost ten teeth. The number of teeth lost does not appear to increase significantly with age. There are no significant differences between males and females in the number of teeth lost antemortem. Table 8.15 shows the ANOVA results for the number of teeth lost antemortem among individuals with any AMTL.

Table 8.15: Two-way ANOVA results for the number of teeth lost antemortem.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	30.174	5	6.035	1.224	0.343
Sex	0.186	1	0.186	0.038	0.849
Age (adults only)	12.482	2	6.241	1.265	0.309
Sex *Age	16.895	2	8.448	1.713	0.212
Error	78.917	16	4.932		
Total	232.000	22			
Corrected Total	109.091	21			

Hypoplastic Enamel Defects

Fifty-five males and 71 females were scored for linear enamel hypoplasia (LEH). The number of individuals with LEH was fairly high compared to the other lesions studied. Overall, 48.2% of males and 44.9% of females expressed at least one hypoplastic defect. There was very little difference by age group in the percentage of individuals affected, ranging from a low incidence of 38.5% in males age 35-50 and a high of 66.7% in males over 50 years of age. Females varied even less by age, ranging from a low incidence of 46.2% among those age 18-35 and a high of 50.0% in those over 50 years of age. There were no significant differences between males and females in any of the age categories. Table 8.16 shows the chi-square results for presence of hypoplastic defects.

Thirty-two juveniles were scored for LEH. More individuals in the 12-18 year age group expressed LEH (43.5%) than in the 6-12 year age group (22.2%) however this number was not statistically significant (p>0.30). Likewise, neither of the juvenile age groups differed significantly from the adults (6-12 p>0.10; 12-18 p>0.70).

Table 8.16: Chi-square results for occurrence of hypoplastic defects (individual count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	55	48.2%	>0.90	71	44.9%
18-35	39	48.7%	>0.70	52	46.2%
35-50	13	38.5%	>0.50	15	46.7%
50+	3	66.7%	>0.70	4	50.0%

Type of hypoplastic defect was scored as groove or pit defects. Both males and females expressed mostly groove defects. Males age 35-50 had the greatest percentage of pit defects of any group, at only 12.5%. In the same age group, there were no pit defects among females. Chi-square tests could not be run on the individual age groups because there were expected frequencies of less than one. Females in the 18-35 and 35-50 year age categories had expected frequencies of less than one. Neither males nor females in the 50+ year age group expressed any pit defects. There were no significant differences between males and females for all age groups combined. Table 8.17 shows the chi-square results for the type of hypoplastic defect.

Table 8.17: Chi-square results for the type of hypoplastic defect (tooth count).

AGE	MALES		P	FEMALES	
	n lesions	% groove		n lesions	% groove
All	88	92.0%	>0.05	138	97.8%
18-35	70	92.9%	NA	104	97.1%
35-50	16	87.5%	NA	29	100%
50+	2	100%	NA	5	100%

Nearly all hypoplastic defects at Hierakonpolis were acute, with chronic hypoplastic defects making up less than five percent of the overall sample. Out of the 291 observed hypoplastic defects, only eight were chronic. Females in the 35-50 year age category had the greatest percentage of chronic defects with 3/41 or 7.3%. Chi-squared tests could not be run for the 35-50 year age group because males in that group experienced only acute hypoplastic defects and therefore had expected frequencies of less than one for chronic defects. No individuals over the age of 50 showed chronic defects. There were no significant differences between males and females in the 18-35 year age group or for all age groups combined. Table 8.18 shows the chi-square results for the severity of hypoplastic defects.

Table 8.18: Chi-square results for severity of hypoplastic defects (defect count).

AGE	**MALES**		**P**	**FEMALES**	
	n lesions	% acute		n lesions	% acute
All	112	94.6%	>0.30	179	97.2%
18-35	92	93.5%	>0.05	131	98.5%
35-50	18	100%	NA	41	92.7%
50+	2	100%	NA	7	100%

Hypoplastic defects were tested as occurring before or after the age of four. Individuals in the 50+ year age group showed the greatest percentage of defects after the age of four (85.7% for both males and females), although the results may be biased due to attrition. For individuals in the other age groups, most defects occurred before the age of four. Age of occurrence of hypoplastic events did not differ between males and females in any of the age categories. Table 8.19 shows the chi-square results for age of occurrence of hypoplastic defects.

Table 8.19: Chi-square results for age of occurrence of hypoplastic defects (defect count).

AGE	**MALES**		**P**	**FEMALES**	
	n lesions	% <4		n lesions	% <4
All	117	62.4%	>0.20	171	56.1%
18-35	92	64.1%	>0.10	123	55.3%
35-50	18	72.2%	>0.50	41	65.9%
50+	7	14.3%	NA	7	14.3%

The individual hypoplastic area (IHA) was very small for all individuals, which is not surprising given the low occurrence of chronic lesions. Table 8.20 shows the ANOVA results for IHA. The mean IHA for males was 0.020 and for females was 0.022. ANOVA shows no significant differences between the age groups or sexes.

Table 8.20: Two-way ANOVA results for individual hypoplastic area.

Source of Variation	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P**
Corrected Model	0.001	9	0.000	0.250	0.986
Sex	0.000	2	0.000	0.260	0.772
Age (adults only)	2.984	3	9.984	0.016	0.997
Sex *Age	0.001	4	0.000	0.448	0.773
Error	0.058	94	0.001		
Total	0.110	104			
Corrected Total	0.059	103			

Macrowear

Macrowear for the maxillary and mandibular first and second molars increases significantly between each age group (p=0.000) for both males and females. Males have higher wear scores on the first molars than females in all age groups. Overall, males have a mean wear score of 24.7 for the maxillary first molars. Females have a mean wear score of 21.8 for the maxillary first molars. ANOVA shows that the difference between the wear scores on the maxillary first molars of males and females is statistically significant. Table 8.21 lists the ANOVA results for macrowear on the maxillary first molars. The mean wear score for the mandibular first molars is 23.4 for males and 20.6 for females. ANOVA shows that the difference between the mandibular first molars of males and females is statistically significant. Table 8.22 lists the ANOVA results for macrowear on the mandibular first molars of males and females.

Males at Hierakonpolis have a mean wear score of 15.1 for the maxillary second molars, while females have a mean wear score of 13.6. ANOVA shows that the difference between males and females is significant. The interaction of sex*age is also significant suggesting that males have greater wear scores in each age group. This is confirmed by independent t tests.

Table 8.21: Two-way ANOVA results for maxillary M1 macrowear.

Source of Variation	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P**
Corrected Model	2058.195	6	342.032	9.933	0.000
Sex	221.372	1	221.372	6.410	0.013*
Age (adults only)	1750.821	3	583.607	14.304	0.000*
Sex *Age	22.008	2	14.504	0.420	0.658
Error	3557.035	103	34.534		
Total	63874.250	110			
Corrected Total	5615.230	109			

*denotes statistically significant differences at the 0.05 level.

Table 8.22: Two-way ANOVA results for mandibular M1 macrowear.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	1941.139	6	323.523	13.870	0.000
Sex	192.421	1	192.421	8.249	0.005*
Age (adults only)	1457.175	3	485.725	20.824	0.000*
Sex *Age	164.024	2	82.012	3.516	0.033*
Error	2542.506	109	23.326		
Total	61755.250	116			
Corrected Total	4483.644	115			

*denotes statistically significant differences at the 0.05 level.

Tables 8.23 and 8.24 list the ANOVA results for the second molars. The mean wear score for the mandibular second molars is 17.0 for males and 14.5 for females. ANOVA shows that the difference between males and females is not significant (see Tables 8.23 and 8.24).

Table 8.23: Two-way ANOVA results for maxillary M2 macrowear.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	1437.635	6	239.606	9.892	0.000
Sex	185.969	1	185.969	7.677	0.007*
Age (adults only)	1323.811	3	441.270	18.271	0.000*
Sex * Age	66.378	2	33.689	1.391	0.253
Error	2640.268	109	24.223		
Total	28830.750	116			
Corrected Total	4077.903	115			

*denotes statistically significant differences at the 0.05 level.

Table 8.24: Two-way ANOVA results for mandibular M2 macrowear.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	1843.351	6	307.255	10.313	0.000
Sex	1515.984	1	505.328	3.742	0.055
Age (adults only)	111.465	3	111.465	16.963	0.000*
Sex * Age	44.405	2	22.202	0.745	0.477
Error	3574.764	120	29.790		
Total	37706.500	127			
Corrected Total	5418.114	126			

*denotes statistically significant differences at the 0.05 level.

The differences between males and females in macrowear on the maxillary first and second molars do reflect sexual differences rather than distribution of sample sizes in the age categories. Males and females have roughly equal frequencies in each age category. The distributions of age and sex do not differ significantly from the expected values for those scored for UM1 ($p = 0.613$), LM1 ($p = 0.408$), UM2 ($p = 0.584$) or LM2 ($p = 0.456$).

Microwear

Micrographs of the Phase II wear facet were examined for 41 males, 60 females, and 22 juveniles from Hierakonpolis. The number of features per micrograph for adults ranged from four to 93. One individual with 70 features and one individual with 93 features were in the 18-35 year age category of unknown sex and were excluded as outliers. Table 8.25 shows the mean number of features by age and sex. The number of microwear features increases with age with the exception of females over 50, which could be due to low sample sizes for that group.

Table 8.25: Number of microwear features by age and sex (untransformed).

AGE	MALES			FEMALES		
	n	range	mean	n	range	mean
All	41	4-58	24.1	60	6-45	22.5
18-35	29	6-51	22.6	44	6-45	21.7
35-50	9	4-58	24.4	13	13-45	25.6
50+	2	19-35	27	3	13-25	20.3

There is very little difference in the mean number of features between males and females of any age group. Table 8.26 shows the ANOVA results for the square-root transformed number of features per micrograph. There were no significant differences in the number of microwear features among any age or sex group. Juveniles showed between four and 66 features per micrograph. Individuals in the 12-18 year age group have significantly more features (p=0.010) than those in the 18-35 year age group. Despite having more features, the percentage of those features that are characterized as pits, as well as the size of the pits and scratches does not differ significantly between the 12-18 year age category and any other group.

Table 8.26: Two-way ANOVA results for microwear feature tally (square-root transformed).

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	4.156	9	0.462	0.322	0.966
Sex	1.604	3	0.280	0.195	0.823
Age (adults only)	0.560	2	0.535	0.373	0.773
Sex *Age	1.754	4	0.439	0.306	0.874
Error	143.477	100	1.435		
Total	2511.000	110			
Corrected Total	147.633	109			

Percentage of the total microwear features that were categorized as pits (versus scratches) ranged from 0% to 79% for adults. A pit is any microwear feature with a length to breadth ratio of less than 4:1. Figure 8.1 is an SEM image that demonstrates pit features. For both males and females, the widest range of pit percentage occurred in the 18-35 year age category. The percentage of pits steadily decreased with age for males, but increased slightly with age for females. Table 8.27 shows the range and mean of pit percentage for males and females for each age group.

Table 8.27: Percentage of features categorized as pits.

AGE	MALES			FEMALES		
	n	range	mean	n	range	mean
All	41	0.09-0.75	0.32	60	0.00-0.79	0.36
18-35	29	0.09-0.75	0.34	44	0.00-0.79	0.35
35-50	9	0.09-0.59	0.29	13	0.11-0.72	0.40
50+	2	0.17-0.26	0.22	3	0.12-0.65	0.39

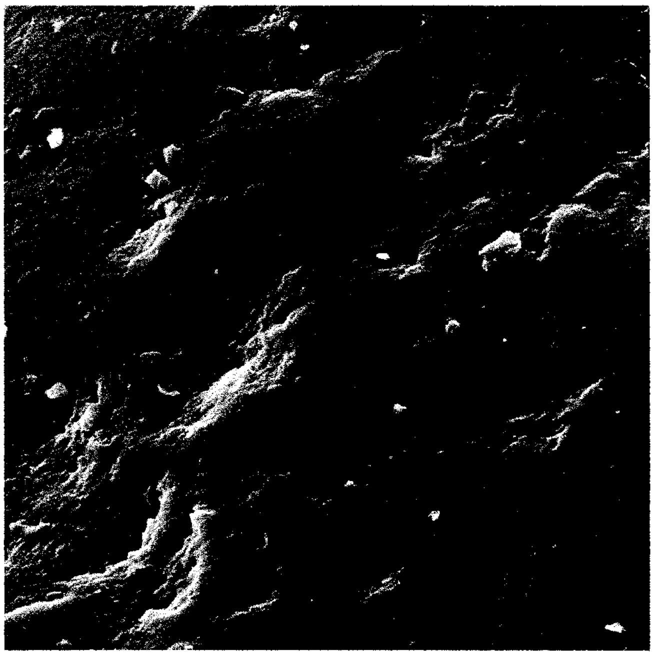

Figure 8.1: Hierakonpolis female age 18-35. (500x) Somewhat atypical female showing a high pit percentage. Image area is 0.25 mm^2.

Mean pit percentage was very similar between males and females of all age groups. There were no significant differences in the percentage of pit features regardless of age or sex. Both males and females had the widest range of pit percentages in the 18-35 age category and the narrowest range in the 50 + age category. Table 8.28 shows the ANOVA results for the percentage of pit features. Pit percentage for juveniles ranged from 0% to 83%, which was slightly larger than the range for the 18-35 age category for males and females. The pit percentage for juveniles did not differ significantly from the adults.

Table 8.28: Two-way ANOVA results for percentage of pits (untransformed).

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	0.194	9	0.022	0.631	0.768
Sex	0.086	2	0.043	1.264	0.287
Age (adults only)	0.082	3	0.027	0.804	0.494
Sex *Age	0.138	4	0.035	1.010	0.406
Error	3.522	103	0.034		
Total	17.155	113			
Corrected Total	3.716	112			

Three males and one female in the 18-35 year age category and one male in the 35-50 age category were removed as outliers because they had mean scratch widths of greater than 6.1 μ. Excluding the outliers, scratch widths ranged from 1.61 μ to 5.99 μ. There are no clear age related trends concerning the width of scratches. Females had the largest scratches in the 50+ year age category, while the largest scratches for males occurred in the 35-50 year age category.

Overall, males had a greater range of scratch widths than females: males having more small scratches than females. Females in the 18-35 and 50+ year age categories had larger scratches than males in those same age categories. Figure 8.2 is an SEM image that illustrates scratches with few pit features. Table 8.29 shows the ranges and means of scratch widths for males and females by age.

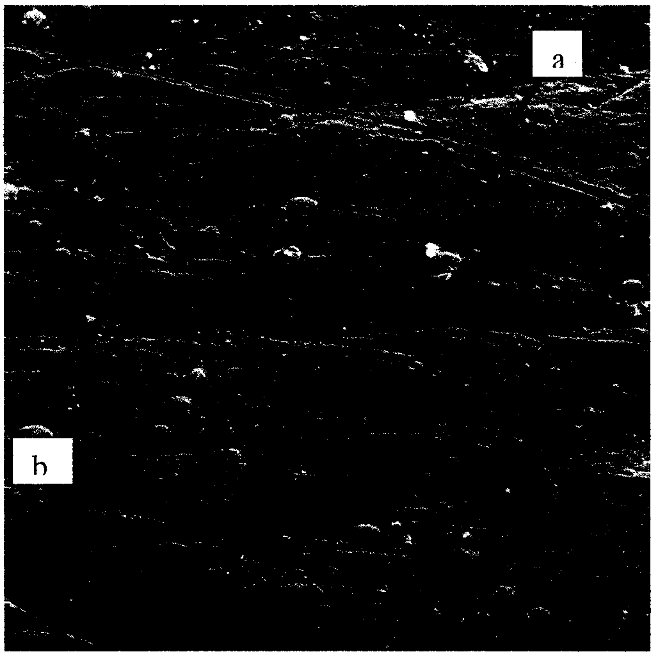

Figure 8.2 Hierakonpolis male age 35-50. (500x) This image shows mostly scratches (a) with few pit features (b). Image area is 0.25 mm^2.

Table 8.29: Scratch width in microns by age and sex (untransformed- includes outliers).

AGE	MALES			FEMALES		
	n	range	mean	n	range	mean
All	41	1.61-9.79	3.52	60	2.01-7.82	3.41
18-35	29	1.66-8.77	3.41	44	2.01-7.82	3.45
35-50	9	2.38-9.79	4.30	13	2.11-3.80	3.09
50+	2	1.61-2.61	2.11	3	3.59-5.22	4.18

There were no significant differences in the mean scratch widths between males and females or between the age groups. The interaction of sex*age shows a significant difference, as a result of the difference between males and females in the 50+ year age group. However, the small sample sizes in these two groups may bias the results. Table 8.30 lists the ANOVA results for the log-transformed scratch widths after the outliers of greater than 6.1 μ have been removed. Scratch width on juveniles ranged from 1.28 μ to 4.22 μ and did not differ significantly from the adults.

Table 8.30: Two-way ANOVA results for scratch width (log-transformed).

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	0.330	9	0.037	2.351	0.019
Sex	0.041	2	0.021	1.329	0.269
Age (adults only)	0.067	3	0.022	1.439	0.236
Sex *Age	0.156	4	0.039	2.509	0.047*
Error	1.527	98	0.016		
Total	27.152	108			
Corrected Total	1.857	107			

* denotes statistically significant differences at the 0.05 level.

As with scratch widths, males also had a greater range of pit widths than females. Pit width for males was greatest in the 50+ year age category, while females in this age group had the smallest pit widths. For males, pit width decreases slightly from the 18-35 year age category to the 35-50 year age category, while females increase slightly between these two age groups. Table 8.31 shows the range and mean of pit width in microns for males and females of each age group.

Table 8.31: Pit width in microns by age and sex (untransformed).

AGE	**MALES**			**FEMALES**		
	n	range	mean	n	range	mean
All	41	2.30-21.08	8.81	60	2.65-18.33	7.70
18-35	29	2.30-20.58	8.83	44	2.65-18.33	7.62
35-50	9	3.95-21.08	8.51	13	3.42-15.34	8.33
50+	2	6.95-12.64	9.80	3	3.59-7.90	6.26

The means of pit widths do not differ significantly between males and females regardless of age group. Table 8.32 lists the ANOVA results for the rank-transformed pit widths. Juveniles have a range of 5.01 μ to 22.25 μ for pit width. Despite having slightly larger pits than the adults, the sizes do not differ significantly and are most likely the result of slightly softer enamel on deciduous dentition (Hillson, 1986).

Table 8.32: Two-way ANOVA results for pit width (rank-transformed).

Source of Variation	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P**
Corrected Model	26857.295	9	2984.144	0.784	0.631
Sex	4476.639	2	2238.319	0.588	0.557
Age (adults only)	7130.977	3	2376.992	0.625	0.601
Sex *Age	13539.385	4	3384.846	0.890	0.473
Error	384286.642	101	3804.818		
Total	1664283.000	111			
Corrected Total	411143.937	110			

Polish is defined by the presence of two or more enamel prisms visible on the micrograph (see Figure 8.3). The occurrence of polish decreased steadily with age for females. Males appear to be more likely to have polish as they get older. The lower occurrence in the 50+ year age category is likely due to small sample size. The difference between males and females who exhibit polish does not differ significantly for any age group. Table 8.33 shows the chi-square results for the percentage of individuals with polish. All juveniles exhibit polish. Juveniles have significantly more individuals with polish ($p<0.001$) than the adults.

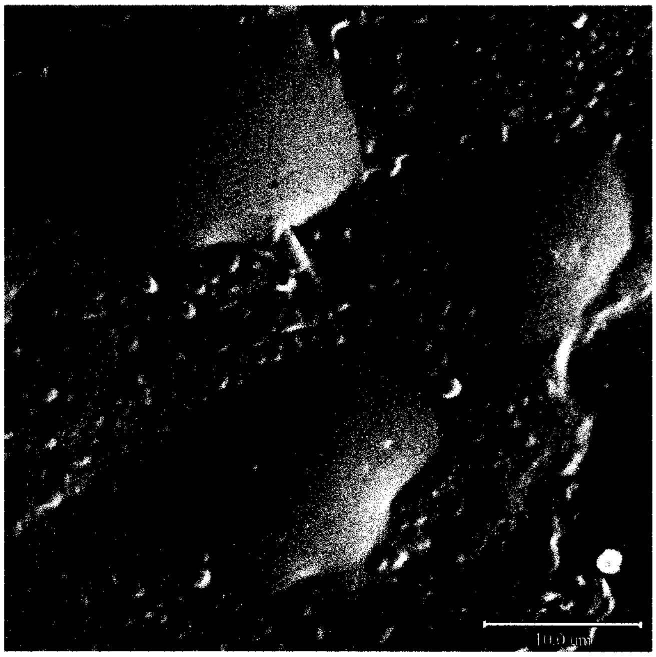

Figure 8.3: Enamel prisms. Close up view of enamel prisms (arrows).

Table 8.33: Chi-square results for occurrence of polish (individual count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	41	68.3%	>0.80	60	66.7%
18-35	29	65.5%	>0.30	44	75.0%
35-50	9	77.8%	>0.10	13	46.1%
50+	2	50.0%	NA	3	33.3%

Of those individuals who exhibit polish, males have a greater range of number of enamel prisms per micrograph than females. Males show the greatest number of enamel prisms in the 35-50 year age category, while females have the greatest number in the 18-35 year age group. The number of enamel prisms decreases slightly with age in females but varies only slightly among age groups in males. Table 8.34 shows the range and mean for number of enamel prisms per micrograph for males and females.

Table 8.34: Number of prisms per micrograph by age and sex.

AGE	MALES			FEMALES		
	n	range	mean	n	range	mean
All	29	2-61	8.93	42	2-31	7.33
18-35	9	2-11	6.16	13	2-31	7.21
35-50	2	3-61	17.00	3	3-12	7.50
50+	1	9	9	1	10	10

Of those individuals with polish, the number of enamel prisms per micrograph was counted to show the amount of polish on the wear facet. The number of enamel prisms does not differ significantly between males and females regardless of age group. Table 8.35 shows the ANOVA results for log-transformed number of prisms per micrograph. Juveniles with polish have between two and 22 enamel prisms visible on each micrograph. Juveniles do not differ significantly from adults in the amount of polish per wear facet.

Table 8.35: Two-way ANOVA results for number of prisms (log-transformed).

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	0.590	8	7.369	0.922	0.504
Sex	6.871	2	3.435	0.430	0.652
Age (adults only)	0.335	3	0.112	1.399	0.251
Sex *Age	0.137	3	4.561	0.571	0.636
Error	5.433	68	7.990		
Total	54.871	77			
Corrected Total	6.023	76			

Within Site Comparisons: Naqada

Carious Lesions

Forty-three males with a total of 469 teeth and 43 females with a total of 469 teeth were scored for carious lesions. One individual in the12-18 year age category expressed an occlusal lesion on a permanent tooth. There were no other carious lesions among the juveniles.

There were no significant differences in the number of males and females with at least one carious lesion in any of the age groups. Table 8.36 shows the chi-square results for the number of individuals with carious lesions. The proportion of males with carious lesions decreases with age, while females remained relatively the same. The highest percentage of males with at least one lesion occurred in the 18-35 year age category, while the highest percentage of females occurred in the 35-50 year age category. The differences between the sexes are generally small.

Table 8.36: Chi-square results for occurrence of carious lesions (individual count).

AGE	**MALES**		**P**	**FEMALES**	
	n	%		n	%
All	43	27.9%	>0.30	43	37.2%
18-35	6	66.7%	>0.20	11	36.4%
35-50	32	21.9%	>0.10	26	38.5%
50+	5	20.0%	>0.80	6	33.3%

After applying Lukacs Caries Correction Factor (Lukacs, 1995), the number of carious teeth among males and females were compared. The percentage of carious teeth among males decreases with age, while the lowest percentage among females occurs in the 35-50 year age category. The number of carious teeth differs significantly between males and females in the 50+ year age category. Males and females in the 18-35 year age and 35-50 year age categories did not differ significantly. Table 8.37 shows the chi-square results for the number of carious teeth. Males have more carious teeth than females up to 50 years of age, however females over 50 have more carious teeth than males.

Table 8.37: Chi-square results for occurrence of carious lesions (corrected tooth count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	469	9.2%	>0.70	469	9.8%
18-35	81	23.2%	>0.05	104	13.7%
35-50	325	6.8%	>0.80	292	6.6%
50+	63	3.4%	<0.02*	73	16.8%

*denotes statistically significant differences at the 0.05 level.

Overall, males had an average of 0.56 carious lesions per individual, while females had an average of 0.58 lesions per individual. Of those individuals with at least one carious lesion, males had an average of 1.9 lesions, whereas females had an average of 1.7 lesions per mouth. Males had the fewest lesions in the 35-50 year age category, while females in the 50+ year age category had the fewest lesions. ANOVA does not show any significant differences for number of lesions per mouth between the sex or age groups. Table 8.38 shows the ANOVA results for the number of carious lesions per mouth. Pearson's Product Moment Correlation Coefficient shows that the number of carious lesions per mouth and calculus severity are very weakly negatively correlated ($r = -0.019$) but this may not be a true correlation ($p = 0.832$). When the p value is not significant, the r value may not be a true representation of the two variables, but may be affected by other variables such as sample size, and thus is not said to be a true correlation (Daniel, 1999).

Table 8.38: Two-way ANOVA results for number of carious lesions per mouth.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	13.636	8	1.705	0.709	0.681
Sex	0.276	2	0.138	0.057	0.944
Age (adults only)	8.294	3	2.765	1.150	0.345
Sex *Age	3.925	3	1.308	0.544	0.656
Error	72.107	30	2.404		
Total	215.000	39			
Corrected Total	85.744	38			

Carious lesion location was scored as occlusal or non-occlusal. Lesions that were too large to assign a surface of origin were not considered, thus excluding most individuals in the 50+ year age category. The majority of lesions were non-occlusal (53.7%). All lesions among females in the 50+ year age category were non-occlusal. Among males, the 35-50 year age category had the greatest number of non-occlusal lesions (69.2%). There were no significant differences between males and females in the 18-35 or 35-50 year age categories. Table 8.39 shows the chi-square results for the location of carious lesions. The 50+ year age category could not be compared because males had only lesions that were too large to be assigned a location.

Table 8.39: Chi-square results for carious lesion location.

AGE	MALES		P	FEMALES	
	n lesions	% occlusal		n lesions	% occlusal
All	24	41.7%	>0.95	21	42.9%
18-35	11	54.5%	>0.70	6	50.0%
35-50	13	30.8%	>0.20	11	54.5%
50+	NA	NA	NA	4	0%

Caries severity was assigned as (1) pin-prick to 1mm, (2) 1mm to 1/4 of the crown, (3) greater than 1/4 of the crown, or (4) complete destruction. Most carious lesions of both males and females were small (1) or medium (2), between a pin-prick and 1/4 of the tooth crown, with the exception of males in the 50+ year age category where the only scorable tooth was completely destroyed. There were no significant differences in the severity of carious lesions between the sexes in any of the age categories. Table 8.40 shows the Mann-Whitney *U* results for severity of carious lesions.

Table 8.40: Mann-Whitney *U* for caries severity.

AGE	MALES				P	FEMALES			
	n	% 1	% 2	% 3		n	% 1	% 2	% 3
All	36	30.1%	44.4%	5.6%	0.442	34	20.1%	50.0%	8.8%
18-35	11	45.4%	45.4%	0%	0.178	9	22.2%	44.4%	11.1%
35-50	17	23.5%	41.2%	11.8%	0.354	13	38.5%	38.5%	7.7%
50+	1	0%	0%	0%	0.280	6	0%	50.0%	16.7%

Calculus

Individuals at Naqada had very little calculus. Most tooth surfaces were scored as either 0 (absent) or 1 (covering less than 1/3 of the surface) for both males and females, regardless of age. Overall, males had more severe calculus than females with the exception of the 18-35 year age category for maxillary anterior teeth and the 35-50 year age category for mandibular anterior teeth. Means of the calculus indices are given in Tables 8.41 and 8.42. The means are not used for statistical comparisons.

Males had a similar amount of calculus in each age category with the exception of the maxillary anterior teeth, where the 18-35 year age category appears much lower and the mandibular anterior teeth where the 35-50 year age group is much lower. A lower amount of calculus on the anterior teeth is most likely the result of small sample sizes for these groups. Females are more varied in the amount of calculus for each age group. Calculus severity appears to increase with age for males, but decreases with age for females on all but the mandibular posterior teeth. When the calculus indices were compared, males and females did not differ significantly among the maxillary (see Table 8.41) or mandibular teeth (see Table 8.42) in any of the age groups.

Table 8.41: Mann-Whitney *U* results for amount of calculus on maxillary teeth.

AGE	**Anterior Teeth**			**Posterior Teeth**		
	Male mean	**P**	**Female mean**	**Male mean**	**P**	**Female mean**
All	0.433	0.349	0.292	0.477	0.993	0.455
18-35	0.000	0.346	0.444	0.523	0.724	0.474
35-50	0.500	0.293	0.310	0.509	0.994	0.468
50+	0.667	0.157	0.000	0.667	0.167	0.202

Table 8.42: Mann-Whitney *U* results for amount of calculus on mandibular teeth.

AGE	**Anterior Teeth**			**Posterior Teeth**		
	Male mean	**P**	**Female mean**	**Male mean**	**P**	**Female mean**
All	0.167	0.283	0.564	0.592	0.726	0.577
18-35	NA	NA	0.642	0.617	0.248	0.310
35-50	0.000	0.277	0.417	0.502	0.991	0.500
50+	NA	NA	NA	0.661	0.658	0.528

Abscess

Abscess expression was very low for the Naqada sample with only 16 of 48 males and 13 of 48 females of known age showing lesions. Despite the low number of affected individuals, there is a trend for the percentage of individuals with at least one abscess to increase with age. The only exception is that females in the 35-50 year age category had the lowest percentage of individuals with an abscess. Pearson's Product Moment Correlation Coefficient shows that abscess and caries severity are positively correlated ($r = 0.290$) and that it is a true correlation ($p = 0.000$).

A greater proportion of females than males had at least one abscess in each age category, except the 35-50 year age group. However, the differences were not statistically significant. Table 8.43 shows the chi-square results for the presence of abscess. No juveniles expressed an abscess.

Table 8.43: Chi-square results for abscess presence (individual count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	48	25.0%	>0.30	48	18.8%
18-35	6	16.7%	>0.80	13	23.1%
35-50	36	22.2%	>0.10	29	6.9%
50+	6	50.0%	>0.99	6	66.7%

There were very few abscesses among the Naqada sample. Of the 29 individuals with abscesses, eight males and six females had only one abscess. Two males and three females had two abscesses. Six males and four female had three or more abscess. Of those individuals affected by abscess, males had an average of 2.2 lesions per mouth, while females had an average of 2.4 per person. Males had a greater number of abscesses per person than females in each of the age categories, except the 18-35 year age group, however those differences were not statistically significant. Table 8.44 shows the ANOVA results for the number of abscesses per mouth.

Table 8.44: Two-way ANOVA results for number of abscesses per mouth.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	23.783	8	2.973	0.843	0.577
Sex	1.440	2	0.720	0.204	0.817
Age (adults only)	3.802	3	1.267	0.359	0.783
Sex *Age	14.309	3	4.770	1.352	0.285
Error	74.083	21	3.528		
Total	252.000	30			
Corrected Total	97.867	29			

Periodontal Disease

Periodontal disease prevalence was very low: only 13 of 49 males and 11 of 48 females of known age expressed a bony lesion. The percentage of males with periodontal disease increases with age, however the lowest proportion of females occurs in the 35-50 year age group. There are no significant differences in the number of individuals with periodontal disease between males and females in the 35-50 or 50+ year age categories or for all age groups combined. Table 8.45 shows the chi-square results for the presence of periodontal disease. Chi-square tests could not be run for the 18-35 year age category because males had expected frequencies of less than one. There were no juveniles with periodontal bone loss.

Table 8.45: Chi-square results for occurrence of periodontal disease (individual count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	69	20.3%	>0.50	71	16.9%
18-35	6	0.00%	NA	13	23.1%
35-50	37	21.6%	>0.30	29	13.8%
50+	6	33.3%	>0.99	6	50.0%

The majority of bone loss experienced by both males and females was Type II (vertical bone loss or pockets). Of the 39 teeth affected by periodontal disease in males, 32 teeth from 12 individuals had vertical bone loss, while of 27 affected teeth in females, 24 teeth from 12 individuals had vertical bone loss. Two males and one female experienced both Type I and Type II periodontal disease. Horizontal and vertical bone loss occurred in separate quadrants in all individuals. There are too few individuals affected by periodontal disease to make comparisons for type of bone loss among different age categories. Males and females do not differ significantly by type of periodontal disease. Table 8.46 shows the chi-square results for type of periodontal disease.

Table 8.46: Chi-square results for type of periodontal disease (tooth count)

AGE	MALES			P	FEMALES		
	n lesions	% Type I	% Type II		n lesions	% Type I	% Type II
Combined due to sample size	39	17.9%	82.1%	>0.50	27	11.1%	88.9%

The extent of root exposure was measured for all teeth with horizontal (Type I) bone loss. ANOVA shows that amount of root exposure does not differ significantly by age or by sex. Table 8.47 shows the ANOVA results for the amount of root exposure. Males had a mean root exposure of 6.52 mm, while females had a mean root exposure of 7.00 mm. There are too few individuals with Type I periodontal disease to discern any age related trends in the amount of root exposure. There were not enough individuals with horizontal bone loss for ANOVA to calculate the interaction of sex*age.

Table 8.47: Two-way ANOVA results for amount of root exposure.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	11.563	3	3.884	0.875	0.525
Sex	3.000	1	3.000	0.675	0.376
Age (adults only)	11.221	2	5.611	1.263	0.457
Sex *Age	0.000	0	NA	NA	NA
Error	17.767	4	4.442		
Total	388.540	8			
Corrected Total	29.420	7			

Teeth were scored for surface of vertical bone loss as (1) a one-surfaced crater, (2) a two-surfaced crater (3) a trench, or (4) a moat. Males exhibited mostly one-surfaced craters while females exhibit nearly evenly distributed among all categories. The differences between males and females are not statistically significant. There are not enough individuals with periodontal disease to make comparisons among each age group. Table 8.48 shows the Mann-Whitney *U* results for the surface of vertical bone loss.

Table 8.48: Mann-Whitney *U* results for surface of vertical bone loss (tooth count).

AGE	MALES				P	FEMALES			
	n	% 1	% 2	% 3		n	% 1	% 2	% 3
Combined due to sample Size	27	44.4%	18.5%	11.1%	0.275	22	22.7%	27.3%	22.7%

Antemortem Tooth Loss

Many individuals at Naqada experienced at least some antemortem tooth loss (AMTL). Males and females with the smallest proportion of individuals with AMTL are in the 35-50 year age category. In the 50+ year age category, there are slightly more females with AMTL than males, but more males than females in the 35-50 and 18-35 year age categories. None of these differences are statistically significant. Table 8.49 shows the chi-square results for antemortem tooth loss. Chi-square tests could not be run for the 50+ age category because males had expected frequencies of less than one. No juveniles experienced antemortem tooth loss that was unrelated to the natural shedding of deciduous teeth.

Table 8.49: Chi-square results for occurrence of AMTL (individual count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	52	34.6%	>0.80	52	32.7%
18-35	7	42.9%	>0.70	13	38.5%
35-50	39	25.6%	>0.30	32	18.8%
50+	6	83.3%	NA	7	85.7%

Of the 18 males who experienced AMTL, nine lost more than one tooth. Only one male in the 18-35 year age group lost more than one tooth, however that individual lost 10 teeth. Within the 35-50 year age category, one male lost two teeth, one lost five teeth and one lost 16 teeth. Males in the 50+ year age group lost two, three, four, six, and eight teeth respectively. Of the 17 females who experienced AMTL, five lost only one tooth. Within the 18-35 year age group two females lost three teeth and one lost six teeth. Females in the 35-50 year age category lost two, three, four, seven, and 16 teeth respectively. Females in the 50+ year age group lost four, six, seven, and eight teeth. The number of teeth lost does tend to increase with age for both males and females. There are no significant differences for the number of teeth lost antemortem between males and females. Table 8.50 shows the ANOVA results for number of teeth lost antemortem.

Table 8.50: Two-way ANOVA results for the number of teeth lost antemortem.

Source of Variation	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P**
Corrected Model	116.764	7	16.681	2.158	0.041
Sex	3.520	1	3.520	0.455	0.501
Age (adults only)	96.561	3	32.187	4.165	0.007*
18-35 v 35-50	-	1	-	-	0.559
35-50 v 50+	-	1	-	-	0.001*
18-35 v 50+	-	1	-	-	0.011*
Sex *Age	15.149	3	5.050	0.653	0.582
Error	1081.959	140	7.728		
Total	1435.000	148			
Corrected Total	1198.723	147			

*denotes statistically significant differences at the 0.05 level.

Hypoplastic Enamel Defects

Overall, 24.3% of males and 13.9% of females were affected by hypoplastic enamel defects. The percentage of individuals with at least one hypoplastic defect decreased with age for both males and females. No individuals over 50 years of age expressed hypoplastic defects. Males and females in the 18-35 year age category had equal proportions of individuals with hypoplastic defects. There were no significant differences between males and females in any of the age categories. Table 8.51 shows the chi-square results for presence of hypoplastic defects. Ten juveniles were scored for LEH, all of whom were in the 12-18 year age group. Three of the ten juveniles expressed hypoplastic defects. The number of juveniles with hypoplastic defects did not differ from the adults ($p > 0.70$).

Table 8.51: Chi-square results for occurrence of hypoplastic defects (individual count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	37	25.5%	>0.20	36	13.9%
18-35	6	33.3%	>0.50	9	33.3%
35-50	28	25.0%	>0.10	26	7.7%
50+	3	0%	NA	1	0%

Chi-Square for type of hypoplastic defect was not calculated for the Naqada sample because no individuals expressed pit defects. All defects for males, females, and juveniles were linear horizontal groove defects.

The majority of hypoplastic defects at Naqada were acute. All hypoplastic defects among 18-35 year olds were acute. Among the 35-50 year olds, no females expressed acute lesions and only 33.3% of males expressed acute lesions. No individuals over the age of 50 showed scorable lesions. There were no significant differences between males and females for all age groups combined. Table 8.52 shows the chi-square results for hypoplastic defect severity.

Table 8.52: Chi-square results for severity of hypoplastic defects (defect count).

AGE	MALES		P	FEMALES	
	n lesions	% acute		n lesions	% acute
Combined	32	68.8%	>0.70	6	66.7%
18-35	17	100%	NA	4	100%
35-50	15	33.3%	NA	2	0%
50+	0	NA	NA	0	NA

Hypoplastic defects were tested as occurring before or after the age of four. Among females, only individuals of unknown age showed hypoplastic defects that formed before the age of four. Males in the 18-35 year age category had formed the majority of lesions before the age of four. No individuals over 50 showed scorable lesions. Age of occurrence of hypoplastic events did not differ between males and females for the 18-35 year age group or for all age groups combined. Table 8.53 shows the chi-square results for the age of occurrence of hypoplastic defects.

Table 8.53: Chi-square results for the age of occurrence of hypoplastic defects.

AGE	MALES		P	FEMALES	
	n lesions	% <4		n lesions	% <4
Combined	37	35.1%	>0.80	13	30.8%
18-35	17	52.9%	>0.10	4	0%
35-50	14	23.1%	NA	2	0%
50+	0	0%	NA	0	NA

The individual hypoplastic area (IHA) was very small for all individuals, which is not surprising given the low occurrence of chronic hypoplastic defects. The mean IHA for males was 0.045 and for females was 0.012. There are no clear age related trends for IHA. ANOVA shows no significant differences in individual hypoplastic area between the sexes or age groups. Table 8.54 shows ANOVA results for individual hypoplastic area. There were not enough individuals for ANOVA to calculate the interaction between sex*age. Only eight individuals had the four or more polar teeth that were required to formulate individual hypoplastic area.

Table 8.54: Two-way ANOVA results for individual hypoplastic area.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	0.003	3	0.001	1.525	0.338
Sex	0.002	1	0.002	3.322	0.142
Age (adults only)	0.001	2	0.000	0.466	0.658
Sex *Age	0.000	0	NA	NA	NA
Error	0.003	4	0.001		
Total	0.012	8			
Corrected Total	0.005	7			

Macrowear

Macrowear for maxillary and mandibular first molars and maxillary second molars increased significantly among each age group when the sexes were combined. The amount of macrowear does not differ among the age groups for the mandibular second molars. Overall males have a slightly higher wear score than females on the maxillary first molars, while females have a slightly higher wear score on the mandibular first molars. Males have a mean wear score of 24.5 for maxillary first molars. Females have a mean wear score of 23.8 for the maxillary first molars. The mean wear score for the mandibular first molars is 24.2 for males and 25.8 for females. ANOVA shows that the difference between males and females is not significant for the maxillary or mandibular first molars regardless of age group. Tables 8.55 and 8.56 show the ANOVA results for the amount of macrowear on the maxillary and mandibular first molars respectively.

Table 8.55: Two-way ANOVA results for maxillary M1 macrowear.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	1556.797	9	172.977	2.711	0.008
Sex	29.346	2	14.673	0.230	0.795
Age (adults only)	1152.574	3	384.191	6.020	0.001*
Sex *Age	191.737	4	47.934	0.751	0.560
Error	5488.200	86	63.816		
Total	62749.750	96			
Corrected Total	7044.997	95			

*denotes statistically significant differences at the 0.05 level.

Table 8.56: Two-way ANOVA results for mandibular M1 macrowear.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	680.407	5	136.081	2.141	0.078
Sex	51.715	1	51.715	0.814	0.372
Age (adults only)	441.243	2	220.621	3.471	0.040*
Sex *Age	99.645	2	49.823	0.784	0.463
Error	2860.505	45	63.567		
Total	34596.250	51			
Corrected Total	3540.912	50			

*denotes statistically significant differences at the 0.05 level.

As with the first molars, males have a higher mean wear score than females on the maxillary second molars, while females have a higher mean wear score than males on the mandibular second molars. Males have a mean wear score of 16.3 for the maxillary second molars, while females have a mean wear score of 16.0. The mean wear score for the lower second molars is 17.3 for males and 17.7 for females. ANOVA shows that the difference between males and females is not significant for maxillary or mandibular second molars. Tables 8.57 and 8.58 show the ANOVA results for the amount of macrowear on the maxillary and mandibular second molars respectively.

Table 8.57: Two-way ANOVA results for maxillary M2 macrowear.

Source of Variation	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P**
Corrected Model	1655.720	9	183.969	2.638	0.010
Sex	55.705	2	27.852	0.399	0.672
Age (adults only)	1499.165	3	499.722	7.166	0.000*
Sex *Age	157.874	4	39.469	0.566	0.688
Error	5927.780	85	69.739		
Total	31903.500	95			
Corrected Total	7583.500	94			

*denotes statistically significant differences at the 0.05 level.

Table 8.58: Two-way ANOVA results for mandibular M2 macrowear.

Source of Variation	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P**
Corrected Model	276.729	5	55.346	0.893	0.495
Sex	107.400	1	107.400	1.733	0.195
Age (adults only)	239.179	2	119.590	1.930	0.158
Sex *Age	81.520	2	40.760	0.658	0.523
Error	2540.430	41	61.962		
Total	17071.250	47			
Corrected Total	2817.160	46			

*denotes statistically significant differences at the 0.05 level.

Microwear

Micrographs of the Phase II wear facet were examined for 25 males, 30 females, and 15 juveniles from Naqada. The number of features per micrograph for adults ranged from nine to 58. Individuals with a feature tally more than three standard deviations from the mean (more than 70 features) were removed as outliers. A 6-12 year old individual with 107 features was excluded as an outlier. Table 8.59 shows the mean number of features by age and sex. Males generally have more features per micrograph than females. The number of microwear features increases with age for both males and females with the exception of individuals over 50, which could be due to low sample sizes for that group.

Table 8.59: Number of microwear features by age and sex (untransformed).

AGE	MALES			FEMALES		
	n	range	mean	n	range	mean
All	25	13-58	32.3	30	9-54	27.7
18-35	5	13-50	27.2	9	16-37	26.3
35-50	15	15-58	32.9	15	9-54	29.7
50+	1	19	19	1	26	26

There is very little difference in the mean number of features between males and females of any age group. Table 8.60 lists the ANOVA results for the square-root transformed number of features per micrograph with outliers of greater than 70 features removed. There were no significant differences in the number of microwear features between any age or sex group. Juveniles showed between six and 107 features per micrograph. The number of microwear features for juveniles does not differ significantly from the adults.

Table 8.60: ANOVA results for microwear feature tally (square-root transformed).

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	11.053	8	1.382	1.182	0.330
Sex	3.180	2	1.590	1.360	0.267
Age (adults only)	2.529	3	0.843	0.721	0.544
Sex *Age	3.824	3	1.275	1.090	0.363
Error	54.949	47	1.169		
Total	1652.000	56			
Corrected Total	66.002	55			

Overall females had a wider range of pit percentage than males: females had both the smallest and largest pit percentage. For females, pit percentage ranged from 0 to 88%, while the overall range for males was seven percent to 70%. The percentage of features characterized as pits decreased with age for females. Males in the 35-50 year age group had the highest percentage of pit features. Table 8.61 shows the range and mean of percentage of pit features for males and females of each age group. Figure 8.4 is an SEM image with a typical pit to scratch ratio.

Table 8.61: Percentage of features categorized as pits.

AGE	**MALES**			**FEMALES**		
	n	range	mean	n	range	mean
All	25	0.07-0.70	0.34	30	0.00-0.88	0.40
18-35	5	0.15-0.70	0.33	9	0.00-0.88	0.45
35-50	15	0.07-0.67	0.35	15	0.00-0.85	0.40
50+	1	0.16	0.16	1	0.35	0.35

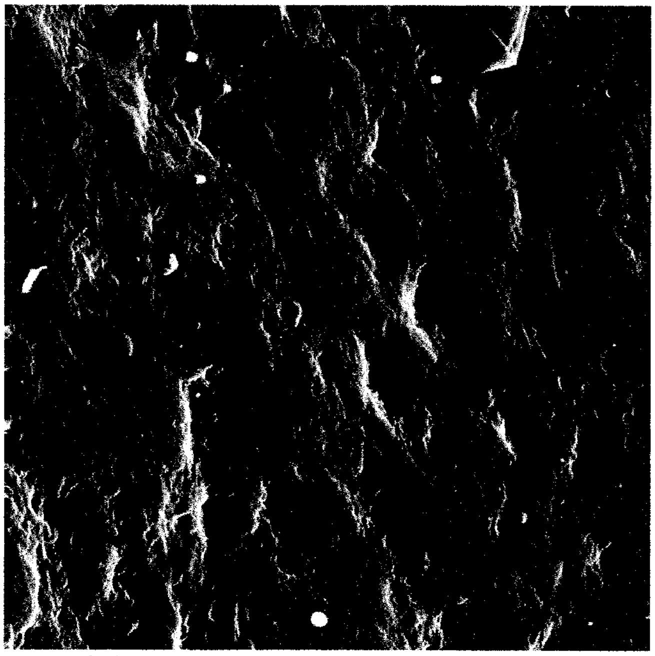

Figure 8.4: Naqada age 6-12. (500x) This is an example of a micrograph with a typical pit: scratch ratio with no polish. Image area is 0.25 mm^2.

There was very little difference in the percentage of pit features between males and females. For both sexes, less than 50% of all features on their micrographs were pit features. Table 8.62 lists the ANOVA results for the untransformed percentage of pit features. ANOVA shows that pit percentage does not differ significantly between males and females regardless of age. Micrographs of juveniles showed between 12% and 85% pit features. Percentage of pit features did not differ significantly between juveniles and adults.

Table 8.62: ANOVA results percentage of pits (untransformed).

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	0.126	5	0.025	0.473	0.794
Sex	0.051	1	0.051	0.957	0.334
Age (adults only)	0.035	2	0.018	0.331	0.720
Sex *Age	0.020	2	0.010	0.187	0.830
Error	2.130	40	0.053		
Total	8.980	46			
Corrected Total	2.256	45			

Scratch width is greater in females than males for every age group. Females also have a wider range of scratch widths than males in every age group. For females the largest scratches occur in the 50+ year age category, while males in this age group have the smallest scratches. For males, scratch width decreases steadily with age. Table 8.63 shows the range and mean of scratch widths in microns for males and females of each age group. Figure 8.5 is an SEM image illustrating a typical range of scratch widths for females.

Table 8.63: Scratch width in microns by age and sex (untransformed- includes outliers).

AGE	MALES			FEMALES		
	n	range	mean	n	range	mean
All	25	1.53-4.78	2.83	27	1.43-6.55	3.20
18-35	5	2.66-3.91	3.39	7	1.53-6.55	3.61
35-50	15	1.53-4.78	2.79	11	1.43-6.16	3.00
50+	1	2.45	2.45	1	4.33	4.33

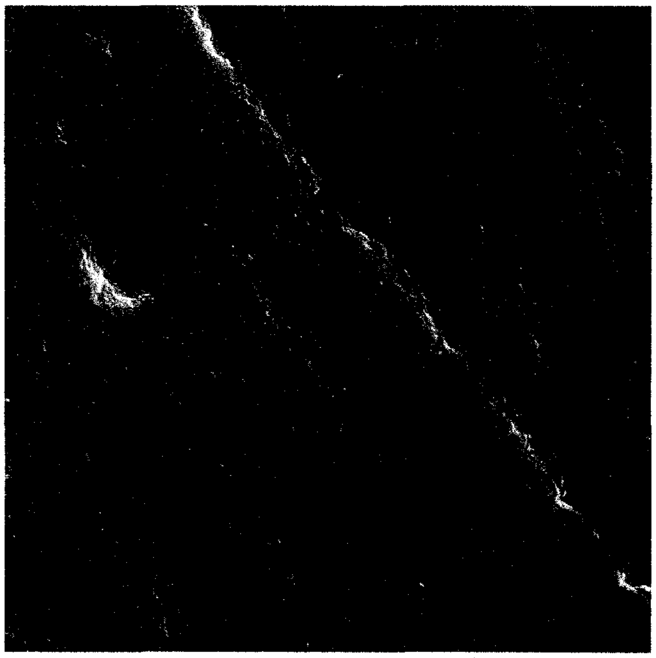

Figure 8.5: Naqada female age 18-35. (500x) Image area is 0.25 mm^2.

Two females in the 18-35 year age category and one female in the 35-50 year age category were excluded as outliers because their scratch widths were greater than 6.10 μ. Excluding outliers, the scratch width for males ranges from 1.53 μ to 4.78 μ, while those for females range from 1.43 μ to 4.33 μ. Table 8.64 shows the ANOVA results for the log-transformed scratch widths. There are no significant differences in scratch widths between males and females regardless of age group. Scratch widths on juveniles ranged from 1.66 μ to 7.59 μ, which is not significantly different from adults.

Table 8.64: ANOVA results for scratch width (log-transformed).

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	0.073	5	0.015	0.324	0.895
Sex	0.001	1	0.001	68.964	0.913
Age (adults only)	0.002	2	0.001	0.012	0.976
Sex *Age	0.023	2	0.012	0.024	0.773
Error	1.674	37	0.045	0.259	
Total	10.947	43			
Corrected Total	1.748	42			

Males have larger pits than females overall and in most of the age categories. Mean pit width is the same for adult males with the exception of the 50+ year age category, which has only one individual. Females have the largest pits in the 18-35 year age category. Table 8.65 shows the range and mean of pit widths in microns for males and females of each age group.

Table 8.65: Pit width in microns by age and sex (untransformed).

AGE	MALES			FEMALES		
	n	range	mean	n	range	mean
All	25	2.87-14.97	7.33	28	1.79-13.30	6.63
18-35	5	5.72-11.45	7.34	8	5.60-13.30	7.87
35-50	15	2.87-14.97	7.34	14	3.55-10.09	5.79
50+	1	11.46	11.46	1	5.84	5.84

Pit width does not differ significantly between males and females for any age group. Table 8.66 shows the ANOVA results for rank-transformed pit width. Juveniles have pit widths ranging from 3.67 μ to 45.74 μ. Individuals in the 12-18 year age category have a range of 5.68 μ to 45.74 μ, which is significantly higher (p=0.002) than those in the 35-50 year age group and those in the 6-12 year age group (p=0.029).

Table 8.66: ANOVA results for pit width (rank-transformed).

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	22191.306	5	4438.261	1.553	0.197
Sex	6949.406	1	6949.406	2.431	0.127
Age (adults only)	7971.453	2	3985.727	1.394	0.260
Sex *Age	7751.404	2	3875.702	1.356	0.270
Error	108620.989	38	2859.447		
Total	487752.500	44			
Corrected Total	130812.295	43			

Twenty percent of all males, and 50% of all females showed evidence of polish. Table 8.67 shows that this difference is statistically significant. When each age group is examined separately there are no significant differences in polish, which may be due to the smaller sample sizes. Only one individual of each sex in the over 50 year age group could be examined; neither of these individuals exhibited polish. No individuals in the 6-12 year age group showed polish, while 60% in the 12-18 year age group did. The percentage of juveniles with polish does not differ significantly from adults.

Table 8.67: Chi-square results for occurrence of polish (individual count).

AGE	MALES		P	FEMALES	
	n	%		n	%
All	25	20.0%	<0.02*	30	50.0%
18-35	5	20.0%	>0.30	9	55.5%
35-50	15	20.0%	>0.10	15	46.7%
50+	1	0%	NA	1	0%

*denotes statistically significant differences at the 0.05 level.

The number of enamel prisms per micrograph was examined for those individuals with polish. Five males and 15 females were examined. On average, females have a greater number of prisms than males. For both males and females the number of prisms increases with age. Table 8.68 shows the number of enamel prisms per micrograph for males and females of each age group.

Table 8.68: Number of prisms per micrograph by age and sex.

AGE	MALES			FEMALES		
	n	range	mean	n	range	mean
All	5	2-6	3.6	15	2-38	8.27
18-35	1	3	3	5	2-7	4.6
35-50	3	2-6	3.67	7	2-10	6.29
50+	0	---	---	0	---	---

Of those individuals with polish, the number of enamel prisms visible on each micrograph does not differ significantly between males and females. Males had between two and six visible enamel prisms per micrograph, while females had between two and 38 prisms per micrograph. This difference was not significant. Table 8.69 shows the ANOVA results for log-transformed prism number. Only juveniles in the 12-18 year age category exhibited polish. Of those, the number of enamel prisms per micrograph ranged from five to 33, which was significantly greater ($p=0.041$) than adults in both the 18-35 and 35-50 year age categories.

Table 8.69: ANOVA results for number of prisms, for individuals with polish (log-transformed).

Source of Variation	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P**
Corrected Model	0.839	5	0.168	2.328	0.098
Sex	0.289	1	0.289	78.579	0.065
Age (adults only)	0.095	2	0.048	4.007	0.531
Sex *Age	0.189	2	0.094	0.662	0.301
Error	1.009	14	0.072	1.308	
Total	12.239	20			
Corrected Total	1.848	19			

Inter-Site Comparisons

Carious Lesions

Neither at Hierakonpolis nor Naqada were there significant differences between the number of males and females with at least one carious lesion. At Hierakonpolis the percentage of males with carious lesions increased with age, whereas the percentage at Naqada decreases with age. The percentage of females at Hierakonpolis with carious lesions also decreases with age. At Naqada, the 35-50 year age group shows the greatest proportion of affected individuals, however the percentage of females with lesions changes very little with age. Nevertheless, the number of individuals with at least one carious lesion does not differ significantly between the two samples, regardless of sex or age. Table 8.70 shows the chi-square results for carious lesions.

No individuals in the 6-12 year age group from Naqada and only one individual from Hierakonpolis expressed carious lesions. In the 12-18 year age group, one individual from Hierakonpolis and one individual from Naqada had an occlusal lesion on a permanent tooth. Chi-square tests could not be performed for either age group because the Naqada sample had expected frequencies of less than one.

Table 8.70: Chi-square results for occurrence of carious lesions (individual count).

AGE	Hierakonpolis		P	Naqada	
	n	%		n	%
Males	66	36.4%	>0.30	59	28.8%
18-35	40	35.0%	>0.20	6	66.7%
35-50	16	43.8%	>0.10	32	21.9%
50+	5	40.0%	>0.99	5	20.0%
Females	78	35.9%	>0.30	56	28.6%
18-35	54	38.9%	>0.80	11	36.4%
35-50	16	31.2%	>0.50	26	38.5%
50+	6	16.7%	>0.99	6	33.3%
Juveniles	32	3.4%	NA	11	9.1%
6-12	9	11.1%	NA	2	0%
12-18	23	4.3%	NA	9	11.1%

There were no significant differences in the number of teeth (corrected) with carious lesions between males and females of any age group at Hierakonpolis. However males and females in the 35-50 and the 50+ year age group at Naqada differed at the 0.01 level. While the 18-35 year age group at Naqada does not differ significantly ($p > 0.05$), males (23.2%) and females (13.7%) at Naqada differ more from each other than males (3.4%) and females (3.1%) in the same age group at Hierakonpolis ($p > 0.70$).

Males in the 18-35 year age group differed significantly between the samples for the number of teeth (corrected) with at least one carious lesion. Males in the 35-50 and 50+ year age groups did not differ significantly between the samples. The number of teeth (corrected) differed significantly between the samples for females in the 18-35 and

50+ age groups, but not for the 35-50 year age group. Table 8.67 shows the chi-square results for carious lesion tooth count frequencies.

Chi-square tests could not be run for the 6-12 year age group because the Naqada sample had expected frequencies of less than one. There was no significant difference between Naqada and Hierakonpolis in the 12-18 year age group (see Table 8.71).

Table 8.71: Chi-square results for occurrence of carious lesions (corrected tooth count).

AGE	Hierakonpolis		P	Naqada	
	n	%		n	%
Males	1127	3.9%	<0.01*	469	9.2%
18-35	767	3.4%	<0.01*	81	23.2%
35-50	272	5.5%	>0.30	325	6.8%
50+	89	3.4%	>0.50	63	3.4%
Females	1476	3.1%	<0.01*	469	9.8%
18-35	1034	3.1%	<0.01*	104	13.7%
35-50	311	4.0%	>0.10	292	6.6%
50+	131	1.5%	<0.01*	73	16.8%
Juveniles					
6-12	170	0.6%	NA	14	0%
12-18	402	0.2%	>0.70	61	1.6%

* denotes statistically significant differences at the 0.05 level.

The number of carious lesions per mouth did not differ significantly between males and females at either Hierakonpolis or Naqada. Males at Hierakonpolis had an average of 2.2 lesions per mouth, while males at Naqada had an average of 1.9 lesions per mouth. At Hierakonpolis, females had an average of 1.8 lesions per individual, while 1.7 was the average for females at Naqada. The differences between inhabitants of the sites were not significant regardless of sex or age group. Table 8.72 shows the three-way ANOVA results for number of carious lesions per mouth. The three-ANOVA table is similar to the two-way ANOVA table, discussed on page 154, except there are three main effects 'Site', 'Sex' and, 'Age'. The interactions between the main effects include 'Site*Sex', 'Site*Age', 'Sex*Age', and the interaction of all three main effects 'Site*Sex*Age'. The main effects of 'Sex' and 'Age' and the interaction of 'Sex*Age' are not listed here as they were already examined in the intra-site comparisons.

Table 8.72: Three-way ANOVA results for number of lesions per mouth (of those affected).

Source of Variation	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P**
Corrected Model	23.405	11	2.128	0.923	0.524
Site	0.290	1	0.290	0.126	0.724
Site*Sex	0.471	1	0.205	0.205	0.653
Site*Age (adults)	14.185	2	7.029	3.078	0.053
Site*Sex*Age	3.547	2	1.774	0.770	0.467
Error	154.393	67	2.304		
Total	478.000	79			
Corrected Total	177.797	78			

Carious lesion location was recorded as occlusal or non-occlusal. This analysis did not consider lesions that were too large to assign a surface of origin, thus excluding most of those in the 50+ year age groups. Neither sample showed differences in carious lesion location between males and females in the 18-35 or 35-50 year age groups. Chi-square could not be run for the 50+ year age group for either sample, due to expected frequencies of less than one. The majority of lesions at both Hierakonpolis and Naqada were occlusal. Males of both samples showed the greatest percentage of non-occlusal lesions in the 35-50 year age group. At Hierakonpolis, females also showed the greatest percentage of non-occlusal lesions in the 35-50 year age group, however, at Naqada, the percentage was slightly higher in the 18-35 year age category. There were no differences in the location of carious lesions between the samples for any age or sex group. Table 8.73 shows the chi-square results for carious lesion location. No males over the age of 50 from either sample expressed non-occlusal lesions. No females from Naqada over the age of 50 expressed non-occlusal lesions. All carious lesions on juveniles were occlusal.

Table 8.73: Chi-square results for carious lesion location.

AGE	**Hierakonpolis**		**P**	**Naqada**	
	n lesions	% occlusal		n lesions	% occlusal
Males	36	61.1%	>0.20	24	44.0%
18-35	22	77.3%	>0.70	11	54.5%
35-50	14	35.7%	>0.80	13	30.8%
50+	0	NA	NA	0	NA
Females	41	56.1%	>0.30	21	65.2%
18-35	30	60.0%	1.00	6	50.0%
35-50	9	44.4%	1.00	11	54.5%
50+	2	50.0%	NA	4	0%

The majority of carious lesions at Naqada were small (1) or medium (2), while the majority of those at Hierakonpolis were medium (2). Males and females did not differ significantly in the severity of carious lesions at either site. There were no significant differences between Hierakonpolis and Naqada for males. There was a significant difference between the females when all females were combined, but no significant differences among the individual age categories. Table 8.74 shows the Mann-Whitney *U* results for caries severity.

Table 8.74: Mann-Whitney *U* results for caries severity.

AGE	Hierakonpolis				P	Naqada			
	n	% 1	% 2	% 3		n	% 1	% 2	% 3
Males	44	27.3%	56.8%	4.5%	0.757	29	31.0%	41.4%	6.9%
18-35	26	34.6%	50.0%	3.8%	0.500	11	45.4%	45.4%	0%
35-50	15	20.0%	73.3%	6.7%	0.257	17	23.5%	41.2%	11.8%
50+	3	0%	33.3%	0%	0.564	1	0%	0%	0%
Females	46	34.8%	56.5%	2.2%	0.027*	28	25.0%	42.9%	10.3%
18-35	32	37.5%	56.3%	3.1%	0.110	9	22.2%	44.4%	11.1%
35-50	12	25.0%	58.3%	0%	0.724	13	38.5%	38.5%	7.7%
50+	2	50.0%	50.0%	0%	0.108	6	0%	50.0%	16.7%

*denotes statistically significant differences at the 0.05 level.

Calculus

Calculus severity was slight at both Hierakonpolis and Naqada. Most tooth surfaces of both samples exhibited either a 0 (absent) or 1 (less than 1/3 of the tooth surface) score for both males and females. At Hierakonpolis, females had a higher calculus index than males in the 50+ year age category only. At Naqada females had more calculus than males on the maxillary anterior teeth in the 18-35 year age group and mandibular anterior teeth in the 35-50 year age group.

There were no significant differences in calculus severity between males and females at Naqada. However at Hierakonpolis, males had significantly more calculus on the maxillary anterior teeth in the 18-35 year age group and on the maxillary posterior teeth in the 35-50 year age group. Females at Hierakonpolis had significantly more calculus than males on the maxillary posterior teeth in the 50+ year age group.

When all age groups were combined there were no significant differences in calculus severity for males or females between the two sites. Only females over 50 showed significant differences between the two samples. Table 8.75 shows the Mann-

Whitney *U* results for calculus severity among adults. Females over 50 from Hierakonpolis had significantly more calculus on the maxillary posterior teeth than females over 50 from Naqada. There were no other significant differences. Statistical tests could not be performed for mandibular anterior teeth for males in the 18-35 and 50+ year age groups or females in the 50+ year age group because samples from Naqada had no scorable teeth in these categories.

Table 8.75: Mann-Whitney *U* results for adult calculus severity.

AGE	**Males**			**Females**		
	HK mean	**P**	**NQ mean**	**HK mean**	**P**	**NQ mean**
18-35						
Upper Anterior	0.460	0.196	0.000	0.287	0.534	0.444
Upper Posterior	0.462	0.725	0.523	0.422	0.483	0.476
Lower Anterior	0.654	NA	NA	0.576	0.789	0.643
Lower Posterior	0.582	0.809	0.617	0.474	0.328	0.310
35-50						
Upper Anterior	0.453	0.691	0.500	0.212	0.788	0.310
Upper Posterior	0.705	0.206	0.509	0.361	0.246	0.468
Lower Anterior	0.626	0.139	0.000	0.618	0.391	0.417
Lower Posterior	0.647	0.250	0.502	0.444	0.616	0.500
50+						
Upper Anterior	0.307	0.373	0.667	0.533	0.105	0.000
Upper Posterior	0.168	0.100	0.667	0.708	0.011*	0.202
Lower Anterior	0.675	NA	NA	0.861	NA	NA
Lower Posterior	0.538	0.549	0.361	0.835	0.297	0.528

*denotes statistically significant differences at the 0.05 level.

There were no significant differences in the amount of calculus between Hierakonpolis and Naqada for either of the juvenile age categories. Table 8.76 shows the Mann-Whitney *U* results for calculus severity among juveniles. No juveniles from Naqada had scorable lower anterior teeth.

Table 8.76: Mann-Whitney *U* for juvenile calculus severity.

AGE	Upper Anterior			Upper Posterior			Lower Posterior		
	HK mean	P	NQ mean	HK mean	P	NQ mean	HK mean	P	NQ mean
6-12	0.014	NA	NA	0.080	0.603	0.037	0.061	0.569	0.000
12-18	0.242	0.368	0.333	0.214	0.667	0.138	0.209	0.138	0.437

Abscess

At both Hierakonpolis and Naqada, males were slightly more likely to have an abscess than females. However, neither sample showed statistically significant differences between the number of males and females with at least one abscess. At both Hierakonpolis and Naqada, the percentage of males with at least one abscess increased with age, while females had the lowest percentage of individuals with abscess in the 35-50 year age category.

The number of males with at least one abscess did not differ significantly between the samples. Females in the 35-50 year age category from Hierakonpolis and males in the 18-35 year age category from Naqada had expected frequencies of less than one, therefore site comparisons of those groups could not be made. There were no significant differences between the samples for females in the 18-35 or 50+ year age groups. However, when all age groups were combined, there were significantly more females from Naqada with at least one abscess than from Hierakonpolis. Table 8.77 shows the chi-square results for abscess presence. There were no juveniles with abscesses from either site.

Table 8.77: Chi-square results for abscess presence (individual count).

AGE	Hierakonpolis		P	Naqada	
	n	%		n	%
Males	63	12.7%	>0.05	48	25.0%
18-35	42	7.1%	NA	6	16.7%
35-50	16	12.5%	>0.50	36	22.2%
50+	5	60.0%	>0.80	6	50.0%
Females	74	6.8%	<0.05*	48	18.8%
18-35	52	3.8%	>0.05	13	23.1%
35-50	16	0%	NA	29	6.9%
50+	6	50.0%	>0.99	6	66.7%

*denotes statistically significant differences at the 0.05 level.

Males and females did not differ significantly in the number of abscesses per mouth at either site. Males had more abscesses than females at Hierakonpolis, whereas females had more abscesses than males at Naqada. Of individuals with abscess, males at Hierakonpolis had an average of 1.9 abscesses per mouth, while females had an average of 1.6 per mouth. At Naqada, males had an average of 2.2 abscesses per mouth, while females had an average of 2.4 abscesses per mouth.

Individuals at Naqada appear to have a greater number of abscesses per mouth than those at Hierakonpolis. The most abscesses expressed by any individual at Hierakonpolis are 10. The most abscesses expressed by any individual at Naqada are 16. However these differences are not statistically significant regardless of sex or age group. Table 8.78 shows the ANOVA results for the number of abscesses per mouth of individuals with at least one abscess.

Table 8.78: Three-way ANOVA results for number of abscesses per mouth.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	34.671	11	3.152	0.912	0.545
Site	4.524	1	4.524	1.309	0.264
Site*Sex	2.350	1	2.350	0.680	0.418
Site*Age (adults)	5.457	2	2.729	0.789	0.466
Site*Sex*Age	4.301	1	4.301	1.244	0.276
Error	79.500	23	3.457		
Total	288.000	35			
Corrected Total	114.171	34			

Periodontal Disease

Periodontal disease prevalence was fairly low in both samples. In most cases, periodontal disease increases with age. The only exception is among females at Naqada, where the lowest percentage of affected individuals was in the 35-50 year age group. Males and females did not differ significantly in periodontal disease prevalence at either site.

The number of males with periodontal disease did not differ significantly between the sites when all age groups were combined, or for the 35-50 or 50+ year age categories. Chi-square tests could not be run between the sites for males in the 18-35 year age group because the Naqada sample had expected frequencies of less than one. Occurrence of periodontal disease among females differed significantly between the samples when all age groups were combined. Females from Naqada in the 18-35 year age group had expected frequencies of less than one. Females in the 35-50 and 50+ year age groups did not differ significantly between the samples. Table 8.79 shows the chi-square results for periodontal disease presence. There were no juveniles with periodontal disease from either site.

Table 8.79: Chi-square results for occurrence of periodontal disease (individual count).

AGE	Hierakonpolis		P	Naqada	
	n	%		n	%
Males	67	9.0%	>0.05	69	20.3%
18-35	42	4.8%	NA	6	0%
35-50	16	12.5%	>0.50	37	21.6%
50+	5	40.0%	>0.70	6	33.3%
Females	74	8.1%	<0.05*	48	20.8%
18-35	52	1.9%	NA	13	23.1%
35-50	16	18.8%	>0.80	29	13.8%
50+	6	3.3%	>0.99	6	50.0%

*denotes statistically significant differences at the 0.05 level.

Neither sample showed significant differences between males and females in the type of bone loss. There were too few individuals at either site with periodontal disease to make comparisons for type of bone loss for separate age categories. The majority of individuals at Hierakonpolis experienced Type I (horizontal or generalized) periodontal disease. The majority of individuals at Naqada experienced Type II (vertical or pockets) periodontal disease. Both males and females differed significantly in the type of periodontal disease between the samples. Table 8.80 shows the chi-square results for type of periodontal disease.

Table 8.80: Chi-square results for type of periodontal disease (tooth count).

	Hierakonpolis			P	Naqada		
	n	% Type I	% Type II		n	% Type I	% Type II
Males	11	72.8%	27.2%	<0.01*	39	17.9%	82.1%
Females	13	61.5%	38.5%	<0.01*	27	11.1%	88.9%

*denotes statistically significant differences at the 0.05 level.

There is a significant difference in the amount of root exposure for Type I periodontal disease between males and females at Hierakonpolis but not at Naqada. The mean root exposure for males was 5.68 mm at Hierakonpolis and 6.52 mm at Naqada. Females at Hierakonpolis had a mean root exposure of 3.33 mm. Females at Naqada had a mean root exposure of 7.00 mm. ANOVA shows that there is a significant difference in the amount of root exposure between the sites and in the site*sex comparison. Table 8.81 shows the ANOVA results for the amount of root exposure. Independent samples *t* tests show that the difference between females at the two sites is significant at the 0.05 level, while the difference between males is not. Sample sizes were too small for the site*sex*age comparison.

Table 8.81: Three-way ANOVA results for amount of root exposure.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	69.222	9	7.691	3.227	0.022
Site	24.843	1	24.843	10.423	0.006*
Site*Sex	14.822	1	14.822	6.219	0.025*
Site*Age (adults)	7.574	1	7.574	3.178	0.095
Site*Sex*Age	0.000	0	NA	NA	NA
Error	35.752	15	2.383		
Total	763.410	25			
Corrected Total	104.974	24			

*denotes statistically significant differences at the 0.05 level.

There were no significant differences in the number of surfaces affected by vertical bone loss between males and females at Hierakonpolis or Naqada. The number of individuals with periodontal disease was too small at both sites to do a separate comparison for each age category within the sex groups.

Males showed no significant differences between the samples. However females did differ significantly in the surface of vertical bone loss between the samples. Table 8.82 shows the Mann-Whitney *U* results for surface of bone loss. At Hierakonpolis females were affected on only one side of the tooth with the exception of one individual. Eighty percent of the females at Naqada were affected on two or more sides of the tooth, with 25% showing a 'moat', or all four sides affected by periodontal bone loss.

Table 8.82: Mann-Whitney *U* results for surface of vertical bone loss (tooth count).

	Hierakonpolis				P	Naqada			
	n	% 1	% 2	% 3		n	% 1	% 2	% 3
Males	3	33.3%	33.3%	33.3%	0.852	27	44.4%	18.5%	11.1%
Females	6	83.3%	0%	0%	0.039*	22	22.7%	27.3%	22.7%

*denotes statistically significant differences at the 0.05 level.

Antemortem Tooth Loss

Antemortem tooth loss (AMTL) frequency does not differ between males and females at either site. The percentage of individuals at Hierakonpolis with AMTL increased with age for both sexes. At Naqada, both males and females had the lowest percentage of individuals with AMTL in the 35-50 year age category. No juveniles at either site experienced AMTL that was not related to the natural shedding of deciduous teeth.

When all age groups were combined, significantly more males at Naqada experienced AMTL than at Hierakonpolis. However, when age groups are compared separately, males show no significant differences between the samples. Table 8.83 shows the chi-square results for antemortem tooth loss. Males in the 18-35 year age group at Naqada had expected frequencies of less than one. If sample sizes were larger, males between 18-35 years would most likely differ significantly between Hierakonpolis and Naqada.

Females also differ significantly between the samples. When all age groups are combined, significantly more females at Naqada have AMTL than at Hierakonpolis (see Table 8.83). When the age groups are tested separately, the only age category among females to show significant differences is the 18-35 year age group. However, if sample sizes were higher, the 50+ year age group would also likely be significantly different between sites.

Table 8.83: Chi-square results occurrence of antemortem tooth loss (individual count).

AGE	Hierakonpolis		P	Naqada	
	n	%		n	%
Males	65	18.5%	<0.05*	52	34.6%
18-35	44	6.8%	NA	7	42.9%
35-50	16	62.5%	>0.30	39	25.6%
50+	5	60.0%	>0.80	6	83.3%
Females	80	12.5%	<0.01*	52	32.7%
18-35	56	7.1%	<0.01*	13	38.5%
35-50	18	22.2%	>0.80	32	18.8%
50+	6	33.3%	>0.10	7	85.7%

*denotes statistically significant differences at the 0.05 level.

The number of teeth lost antemortem does not differ significantly between males and females at either site. At Hierakonpolis the number does increase significantly with age. Individuals over 50 years of age at Naqada have lost significantly more teeth than the other two age groups. Overall there is significantly more AMTL at Naqada than at Hierakonpolis. Table 8.84 shows the ANOVA results for the number of teeth lost antemortem. However, the site*sex and site*sex*age comparisons do not show any significant differences.

Table 8.84: Three-way ANOVA results for the number of teeth lost antemortem.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	216.399	14	15.457	3.433	0.000
Site	99.785	1	99.785	7.148	0.008*
Site*Sex	2.379	1	2.379	0.528	0.468
Site*Age (adults)	29.517	3	9.839	2.185	0.090
Site*Sex*Age	8.388	2	4.194	0.931	0.395
Error	1256.311	279	4.503		
Total	1667.000	284			
Corrected Total	1472.711	283			

*denotes statistically significant differences at the 0.05 level.

Hypoplastic Enamel Defects

The number of individuals who experienced linear enamel hypoplasia (LEH) did not differ between males and females at Hierakonpolis or Naqada. At Naqada the percentage of individuals with LEH decreased with age. The percentage of affected females at Hierakonpolis increased with age, while the males with the fewest affected individuals were in the 35-50 year age group.

There were no significant differences between the samples for males in the any of the individual age categories. When all age categories are combined, the difference between the samples is significant at the 0.05 level. Table 8.85 shows the chi-square results for LEH presence.

Females over 50 years of age could not be compared because Naqada had an expected frequency of less than one. When all age groups were combined, Hierakonpolis had significantly more females who were affected by LEH than Naqada. When the age groups were compared separately, there was no significant difference between the samples for females in the 18-35 year age group. Within the 35-50 year age group, females at Hierakonpolis had significantly more individuals with LEH than Naqada (see Table 8.85).

No juveniles in the 6-12 year age group from Naqada could be scored for LEH. Within the 12-18 year age category, juveniles from Hierakonpolis had significantly more individuals with LEH than Naqada (see Table 8.85).

Table 8.85: Chi-square results for occurrence of hypoplastic defects (individual count).

AGE	Hierakonpolis		P	Naqada	
	n	%		n	%
Males	55	47.3%	<0.05*	37	25.5%
18-35	39	48.7%	>0.70	6	33.3%
35-50	13	38.5%	>0.30	28	25.0%
50+	3	66.7%	>0.30	3	0%
Females	71	46.5%	<0.01*	36	13.9%
18-35	52	46.2%	>0.50	9	33.3%
35-50	15	46.7%	<0.01*	26	7.7%
50+	4	50.0%	NA	1	0%
Juveniles	32	40.6%	>0.50	10	30.0%
6-12	9	22.2%	NA	0	NA
12-18	23	43.5%	<0.01*	10	30.0%

*denotes statistically significant differences at the 0.05 level.

Chi-square tests for the type of hypoplastic defect were not run between samples because no individuals from Naqada expressed pit defects. All defects for males, females, and juveniles from Naqada were linear horizontal groove defects. While individuals from Hierakonpolis did exhibit some pit defects the majority were grooves.

The majority of hypoplastic defects at both Hierakonpolis and Naqada were acute. Chi-squared tests could not be run for the 35-50 or 50+ year age categories at either site because of expected frequencies of less than one. Males and females did not differ significantly in the type of hypoplastic defect at either site when the age groups were combined.

Males at Hierakonpolis had significantly more acute lesions than males at Naqada. Females do not differ significantly between the samples. Table 8.86 shows the chi-square results for severity of hypoplastic defects. Adult age groups could not be compared separately for males or females because of expected frequencies of less than one. Juveniles could not be compared because Naqada had expected frequencies of less than one.

Table 8.86: Chi-square results for severity of hypoplastic defects (defect count).

	Hierakonpolis				**Naqada**		
	N	% acute	% chronic	**P**	n	% acute	% chronic
Males	112	94.6%	5.4%	<0.01*	32	68.8%	31.2%
Females	179	97.2%	2.8%	>0.30	6	66.7%	33.3
Juveniles	55	90.9%	9.1%	NA	4	100%	0%
6-12	21	90.5%	9.5%	NA	0	NA	NA
12-18	34	91.2%	8.8%	NA	4	100%	0%

*denotes statistically significant differences at the 0.05 level.

Males and females did not differ significantly in the age of occurrence of hypoplastic defects at Hierakonpolis or Naqada. Males over 50 at Naqada did not have any scorable hypoplastic defects, therefore that age group could not be compared. Males at Hierakonpolis in the 35-50 and combined age categories had significantly more hypoplastic defects that occurred before the age of four than males at Naqada. Males in the 18-35 year age group did not differ significantly between the samples. Table 8.87 shows the chi-square results for age of occurrence of hypoplastic defects.

Females were not separated by age group, because no females of known age from Naqada experienced hypoplastic events before the age of four. There was no significant difference between females at the two sites (see Table 8.87). There was no significant difference between juveniles at the two sites.

Table 8.87: Chi-square results for the age of occurrence of hypoplastic defects.

AGE	Hierakonpolis n	Hierakonpolis % <4	Hierakonpolis % >4	P	Naqada n	Naqada % <4	Naqada % >4
Males	117	62.4%	37.6%	<0.01*	31	38.7%	61.3%
18-35	92	64.1%	35.9%	>0.30	17	52.9%	47.1%
35-50	18	72.2%	27.8%	<0.01*	14	23.1%	76.9%
50+	7	14.3%	85.7%	NA	0	NA	NA
Females	171	56.1%	43.9%	>0.05	13	30.8%	69.2%
Juveniles							
6-12	16	100%	0%	NA	0	NA	NA
12-18	32	50.0%	50.0%	1.00	4	50.0%	50.0%

*denotes statistically significant differences at the 0.05 level.

The individual hypoplastic area (IHA) did not differ significantly between males and females at Hierakonpolis or Naqada. There was no significant difference in the individual hypoplastic area between the samples regardless of age or sex. Table 8.88 shows the ANOVA results for IHA. There were not enough individuals to run a site*sex*age comparison. Only eight individuals from Naqada had four or more polar teeth that were scorable for hypoplastic defects.

Table 8.88: Three-way ANOVA results for individual hypoplastic area.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	4.544	13	3.496	0.569	0.873
Site	5.326	1	5.326	0.867	0.354
Site*Sex	1.946	1	1.946	3.167	0.078
Site*Age (adults)	5.960	2	2.980	0.049	0.953
Site*Sex*Age	0.000	0	NA	NA	NA
Error	6.020	98	6.143		
Total	0.122	112			
Corrected Total	6.475	111			

Macrowear

At Hierakonpolis, males have significantly more macrowear on the maxillary and mandibular first molars than females. There is no significant difference between the sexes at Naqada. Macrowear increases significantly with age at both sites. There is no statistically significant difference in macrowear on the maxillary first molar between the samples. The site*sex analysis for mandibular first molar macrowear is significant between Hierakonpolis and Naqada. Tables 8.89 and 8.90 show the ANOVA results for macrowear on the maxillary and mandibular first molars respectively. A student's *t* test shows that the p value for females for mandibular first molar wear is 0.001, while the p value for males is 0.819.

Table 8.89: Three-way ANOVA results for maxillary M1 macrowear.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	4090.282	20	204.514	4.334	0.000
Site	32338.202	1	32338.202	0.078	0.780
Site*Sex	28.894	2	14.447	0.306	0.737
Site*Age (adults)	51.860	3	17.287	0.336	0.777
Site*Sex*Age	90.146	3	30.049	0.637	0.592
Error	9342.704	198	47.185		
Total	133390.750	219			
Corrected Total	13432.986	218			

Table 8.90: Three-way ANOVA results for mandibular M1 macrowear.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	3605.350	18	200.927	5.446	0.000
Site	2.888	1	2.888	0.079	0.780
Site*Sex	193.164	1	193.164	5.252	0.023*
Site*Age (adults)	89.289	3	29.763	0.809	0.490
Site*Sex*Age	56.634	2	28.317	0.770	0.465
Error	6767.559	184	36.780		
Total	118520.250	203			
Corrected Total	10372.909	202			

*denotes statistically significant differences at the 0.05 level.

Males at Hierakonpolis have significantly greater macrowear on the maxillary second molars than females. There is no significant difference in mandibular second molar macrowear between the sexes at Hierakonpolis. Males and females at Naqada do not differ significantly in the amount of maxillary or mandibular second molar macrowear. The amount of macrowear on the maxillary second molars at both sites increases significantly with age. Macrowear on the mandibular second molar differs significantly with age at Hierakonpolis, but does not differ significantly with age at Naqada.

There is no significant difference in the amount of macrowear on the maxillary second molar between Hierakonpolis and Naqada regardless of sex or age group. The site*sex analysis for mandibular second molar macrowear is significant between the samples. Tables 8.91 and 8.92 show the ANOVA results for the amount of macrowear on the maxillary and mandibular second molars respectively. A student's *t* test for mandibular second molar wear shows that the p value for females is 0.015, while the p value for males is 0.897.

Table 8.91: Three-way ANOVA results for maxillary M2 macrowear.

Source of Variation	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P**
Corrected Model	3800.883	20	190.004	4.418	0.000
Site	0.137	1	0.137	0.003	0.955
Site*Sex	2.098	2	1.049	0.024	0.976
Site*Age (adults)	86.020	3	28.673	0.667	0.547
Site*Sex*Age	63.376	3	21.125	0.491	0.689
Error	8732.714	203	43.018		
Total	64338.250	224			
Corrected Total	12533.597	223			

Table 8.92: Three-way ANOVA for mandibular M2 macrowear.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	2754.310	18	153.017	4.081	0.000
Site	1.665	1	1.665	0.044	0.833
Site*Sex	201.037	1	201.037	5.362	0.022*
Site*Age (adults)	43.935	3	14.645	0.391	0.760
Site*Sex*Age	23.196	2	11.598	0.309	0.743
Error	7199.126	192	37.495		
Total	66200.000	211			
Corrected Total	9953.436	210			

*denotes statistically significant differences at the 0.05 level.

Microwear

Individuals at Naqada have more microwear features per micrograph than individuals at Hierakonpolis in all age and sex categories. Individuals at both sites tend to have the greatest number of microwear features occur in the 35-50 year age category with the exception of males at Hierakonpolis, where the greatest number occurs in the 50+ year age category.

At Naqada, microwear feature number decreases from the 6-12 year age category to a number more similar to adults in the 12-18 year age category. Feature tallies at Hierakonpolis increase from the younger to the older juvenile age categories. Table 8.93 shows the mean number of features for each sample by sex and age.

Table 8.93: Number of microwear features by age and sex for each site.

AGE	Hierakonpolis		Naqada	
	n	mean	n	mean
Males	41	24.1	25	32.3
18-35	29	22.6	5	27.2
35-50	9	24.4	15	32.9
50+	2	27	1	19
Females	60	22.5	30	27.7
18-35	44	21.7	9	26.3
35-50	13	25.6	15	29.7
50+	3	20.3	1	26
Juveniles	22	28.5	13	37.9
6-12	8	23.3	3	62.3
12-18	14	31.5	10	30.5

The mean number of features per micrograph was higher for males at Naqada for all age groups except the 50+ category. All female age groups at Naqada had a greater mean number of features per micrograph than those at Hierakonpolis. Juveniles in the 6-12 year age group had more features per micrograph at Naqada, while those in the 12-18 year age category had more features at Hierakonpolis.

Despite the slightly higher number of features per micrograph at Naqada, there are no significant differences between the samples, regardless of age or sex. Table 8.94 shows the ANOVA results for square-root transformed feature tally. Juveniles did not differ from adults at Naqada but the 12-18 year age-group did differ from the 18-35 year age group at Hierakonpolis. Juveniles did not differ significantly in the number of features per micrograph between the sites.

Table 8.94: Three-way ANOVA results for feature tally (square-root transformed)

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	32.701	18	1.817	1.346	0.168
Site	8.627	1	8.627	0.006	0.936
Site*Sex	1.481	2	0.740	0.549	0.579
Site*Age (adults)	0.838	3	0.279	0.207	0.891
Site*Age (juveniles)	0.694	1	0.694	0.244	0.624
Site*Sex*Age	1.889	2	0.945	0.700	0.498
Error	198.426	147	1.350		
Total	4163.000	166			
Corrected Total	231.127	165			

Mean pit percentage was less than 50% for all sex and age categories at both Hierakonpolis and Naqada. Males at Hierakonpolis and females at Naqada steadily decrease in the percentage of pit features with age. Males at Naqada and females at Hierakonpolis have the greatest percentage of pit features in the 35-50 year age category. Overall, individuals at Naqada have a slightly higher percentage of pit features than individuals at Hierakonpolis. Pit percentage at Naqada decreases from the 6-12 to the 12-18 year age category, while at Hierakonpolis percentage of pit features increases between these two age categories. Table 8.95 shows the mean pit percentage for each sex and age category at Hierakonpolis and Naqada.

Table 8.95: Percentage of features characterized as pits.

AGE	Hierakonpolis		Naqada	
	n	mean	n	mean
Males	41	0.32	25	0.34
18-35	29	0.34	5	0.33
35-50	9	0.29	15	0.35
50+	2	0.22	1	0.16
Females	60	0.36	30	0.40
18-35	44	0.35	9	0.45
35-50	13	0.40	15	0.40
50+	3	0.39	1	0.35
Juveniles	22	0.39	13	0.46
6-12	8	0.44	3	0.48
12-18	14	0.34	10	0.46

There was no difference in the percentage of pits between the sexes, or between juveniles and adults at either site. There was no significant difference in percentage of pits between Hierakonpolis and Naqada regardless of age or sex. Table 8.96 lists the ANOVA results for percentage of pits.

Table 8.96: Three-way ANOVA results for percentage of pits (untransformed)

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	0.273	11	2.478	0.596	0.829
Site	4.593	1	4.593	110.496	0.849
Site*Sex	1.273	1	1.273	0.031	0.861
Site*Age (adults)	1.329	2	6.647	0.160	0.852
Site*Age (juveniles)	5.077	1	5.077	0.996	0.325
Site*Sex*Age	4.176	2	2.088	0.502	0.606
Error	5.570	134	4.157		
Total	24.382	146			
Corrected Total	5.843	145			

There are no clear age-related trends with regard to mean scratch width at Hierakonpolis or Naqada. Overall, the mean scratch widths were slightly larger for males and females at Hierakonpolis than Naqada. However, males in the 50+ year age category and females in the 18-35 and 50+ year age categories had slightly larger scratch widths at Naqada. Juveniles in the 12-18 year age category at Naqada had slightly larger scratch widths than those at Hierakonpolis, while those in the 6-12 year age category had larger scratch widths at Hierakonpolis. Table 8.97 shows the mean scratch widths in microns for Hierakonpolis and Naqada.

Table 8.97: Scratch width in microns by age and sex for each site.

AGE	Hierakonpolis		Naqada	
	n	mean	n	mean
Males	41	3.52	25	2.83
18-35	29	3.41	5	3.39
35-50	9	4.30	15	2.79
50+	2	2.11	1	2.45
Females	60	3.41	27	3.20
18-35	44	3.45	7	3.61
35-50	13	3.09	11	3.00
50+	3	4.18	1	4.33
Juveniles	22	2.89	13	3.96
6-12	8	3.08	3	2.56
12-18	14	2.79	10	3.08

There were no significant differences in scratch widths between the sexes or between juveniles and adults at either site. Table 8.98 lists the ANOVA results for log-transformed scratch width between Hierakonpolis and Naqada. There were no significant differences in scratch width between the samples regardless of age or sex.

Table 8.98: Three-way ANOVA results for scratch width (log-transformed).

Source of Variation	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P**
Corrected Model	0.262	11	2.386	1.002	0.449
Site	4.651	1	4.651	0.195	0.659
Site*Sex	2.974	1	2.974	1.249	0.226
Site*Age (adults)	1.088	2	5.442	0.228	0.796
Site*Age (juveniles)	1.005	1	1.005	0.536	0.469
Site*Sex*Age	2.795	2	1.397	0.587	0.558
Error	3.001	126	2.382		
Total	35.409	138			
Corrected Total	3.264	137			

As with scratch widths, there are no clear age-related trends for pit width at either site. Overall, pit width at Hierakonpolis is slightly larger than at Naqada. However, males in the 50+ year age category and females in the 18-35 year age category had larger pit widths at Naqada than those in the same categories at Hierakonpolis. Males have greater pit widths than females at both Hierakonpolis and Naqada. Juveniles at Naqada have a greater pit width in the 12-18 year age category, while the 6-12 year age category has the greater pit width at Hierakonpolis. At Naqada, the juveniles have slightly greater pit widths overall than the adults, while at Hierakonpolis juveniles pit widths are more comparable to adults. Table 8.99 shows the mean pit widths for all age and sex categories at Hierakonpolis and Naqada.

Table 8.99: Pit width in microns by age and sex for each site.

AGE	Hierakonpolis		Naqada	
	n	mean	n	mean
Males	41	8.81	25	7.33
18-35	29	8.83	5	7.34
35-50	9	8.51	15	7.34
50+	2	9.80	1	11.46
Females	60	7.70	28	6.63
18-35	44	7.62	8	7.87
35-50	13	8.33	14	5.79
50+	3	6.26	1	5.84
Juveniles	21	7.92	13	12.44
6-12	8	8.44	3	5.56
12-18	13	7.60	10	14.50

There were no significant differences in pit width between adult males and females regardless of age at Hierakonpolis or Naqada. At both sites, the pit width tends to increase with age for males and decrease with age for females; however, the age differences are not statistically significant at either site. Individuals in the 12-18 year age category at Naqada have a mean pit width that is statistically significantly higher (p=0.002) than those in the 35-50 year age category. There are no other significant differences in pit width between juveniles and adults at Naqada. Juveniles at Hierakonpolis do not differ significantly from adults. ANOVA shows that there are no statistically significant differences in pit width between Hierakonpolis and Naqada regardless of sex or age category. Table 8.100 lists the ANOVA results for rank-transformed pit width.

Table 8.100: Three-way ANOVA results for pit width (rank-transformed)

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	43299.348	11	3936.304	1.134	0.341
Site	938.617	1	938.617	0.270	0.604
Site*Sex	1477.736	1	1477.736	0.426	0.515
Site*Age (adults)	3905.161	2	1952.581	0.562	0.571
Site*Age (juveniles)	6215.148	1	6215.148	2.050	0.161
Site*Sex*Age	8747.188	2	4373.594	1.260	0.298
Error	451369.131	130	3472.070		
Total	1995384.000	142			
Corrected Total	494668.479	142			

Hierakonpolis had an almost equal percentage of males and females with polish. However, significantly more females ($p<0.02$) than males exhibited polish at Naqada. For both samples, the percentage of females with polish decreased steadily with age. Males at Hierakonpolis are more likely to have polish in the 35-50 year age category, where as males at Naqada have consistently low polish. Table 8.101 shows the percentage of individuals with polish at each site as well as the chi-square results for individuals with polish. Significantly more males at Hierakonpolis exhibit polish than at Naqada. The lack of significant difference between males in the 35-50 year age group may be a result of the low sample size at Naqada. There is no difference between females. Juveniles at Hierakonpolis have significantly more individuals with polish than adults at Hierakonpolis and other juveniles at Naqada.

Table 8.101: Chi-square results for the occurrence of polish (individual count).

AGE	Hierakonpolis			Naqada	
	n	%	P	n	%
Males	41	68.3%	<0.01*	25	20.0%
18-35	29	65.5%	>0.10	5	20.0%
35-50	9	77.8%	<0.01*	15	20.0%
50+	2	50.0%	NA	1	0%
Females	60	66.7%	>0.10	30	50.0%
18-35	44	75.0%	>0.30	9	55.5%
35-50	13	46.1%	>0.99	15	46.7%
50+	3	33.3%	NA	1	0%
Juveniles	22	100.0%	<0.01*	13	40.0%
6-12	8	100.0%	NA	3	0%
12-18	14	100.0%	NA	10	60.0%

*denotes statistically significant differences at the 0.05 level.

Among those individuals with polish, the amount of polish was measured by counting the number of enamel prisms per micrograph (see figure 8.3). Males at Hierakonpolis had a greater number of enamel prisms per micrograph than those at Naqada, which is not surprising given the likelihood of males at Naqada to have polish. Among females and juveniles, individuals at Naqada had a greater number of enamel prisms per micrograph than at Hierakonpolis. Males and females at both sites had the greatest number of enamel prisms per micrograph in the 35-50 year age category. Among juveniles, both samples showed the greatest number of enamel prisms in the 12-18 year age category. Table 8.102 shows the mean number of enamel prisms per micrograph for each sample.

Table 8.102: Number of prisms per micrograph, for individuals with polish.

AGE	Hierakonpolis		Naqada	
	n	mean	n	mean
Males	29	8.93	5	3.6
18-35	9	6.16	1	3
35-50	2	17.00	3	3.67
50+	1	9	0	---
Females	42	7.33	15	8.27
18-35	13	7.21	5	4.6
35-50	3	7.50	7	6.29
50+	1	10	0	---
Juveniles	22	8.55	6	12.83
6-12	8	6.88	0	---
12-18	14	9.50	6	12.83

Of those individuals with polish, the number of enamel prisms per micrograph did not differ significantly between the sexes at Hierakonpolis or Naqada. Juveniles at Naqada had significantly more (p=0.041) enamel prisms per micrograph than adults. There was no significant difference in the number of enamel prisms per micrograph between juveniles and adults at Hierakonpolis. Table 8.103 lists the ANOVA results for log-transformed number of enamel prisms between the samples. Overall adults at Hierakonpolis have significantly more enamel prisms per micrograph than at Naqada. When broken down by age and sex, the sample sizes become too small to show significant differences. The juveniles do not differ significantly in the number of enamel prisms between the samples.

Table 8.103: Three-way ANOVA results for number of prisms, for individuals with polish (log-transformed)

Source of Variation	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	0.894	9	9.938	1.286	0.259
Site	0.346	1	0.346	4.481	0.038*
Site*Sex	8.749	1	8.749	1.132	0.219
Site*Age (adults)	5.140	1	5.140	0.665	0.417
Site (juveniles only)	3.642	1	3.642	0.496	0.488
Site*Sex*Age	8.244	1	8.244	1.066	0.305
Error	5.643	73	7.731		
Total	54.910	83			
Corrected Total	6.538	82			

*denotes statistically significant differences at the 0.05 level.

CHAPTER NINE

DISCUSSION

This chapter goes beyond looking at differences as simply categorical groupings to exploring the processes by which differentiation occurs (Moore, 1994). While the focus of this dissertation is on dentitions from two Predynastic Egyptian populations, the methods employed here can be used for comparing populations from any period worldwide. Other researchers have done similar studies with fewer dental indicators. For example, Schmidt (1998) used macrowear, microwear and caries to differentiate diet in five prehistoric temporal periods in Indiana. Ibrahim (1987) used macrowear, caries, antemortem tooth loss, calculus, abscess, and enamel hypoplasia to reconstruct diet in a number of samples from Egypt and Nubia ranging from the Predynastic to Roman times.

Overall, the working class Predynastic Egyptians at both Hierakonpolis and Naqada had very good dental health; the frequencies of all examined dental diseases are relatively low compared to prehistoric populations from other parts of the world (Baaregaard, 1949; Christophersen and Pederson, 1939; Leigh, 1925; Littleton and Frohlich, 1993; Lukacs, 1992; Schmidt, 1998). If tetracyclines are being produced and ingested by Predynastic Egyptians as some suggest (Mills, 1992), they could be at least partly responsible for the low incidence of pathologies such as abscess and periodontal disease due to their antibiotic effect. While chapter Eight illustrates that the expression of dietary indicators on the dentition appears quite similar between Hierakonpolis and Naqada, the differences that do exist are great enough to warrant a separate discussion for each sample.

Diet and Dental Health at Hierakonpolis

As shown in Table 9.1, when differences between the sexes occur, males tend to express the dietary indicator to a greater extent than do females. However, not all of these differences may be directly related to diet. Calculus severity differs only on the maxillary teeth and only among certain age groups. Younger males have more calculus on their maxillary teeth than females in the 18-35 and 35-50 year age categories, although in individuals over 50, females have more calculus than males or younger females. While males have similar amounts of calculus on their maxillary and mandibular teeth, the amount of calculus is much higher on the mandibular teeth of females than on their maxillary teeth. Perhaps the women practiced oral cleansing or were performing some task that removes calculus from the surfaces of the maxillary dentition. It should be noted that this potential task does not lead to increased macrowear on the maxillary dentition. Along these lines, a dramatic increase in the amount of calculus on the maxillary dentition of females who reach 50 years of age would then suggest that older females no longer perform this task.

While differences in calculus severity could be related to differences in oral hygiene practices, it seems unlikely that females would stop cleaning their teeth when they reach a certain age. It also seems unlikely that females would clean only their maxillary teeth, and ignore their mandibular teeth. While it is possible in some instance that calculus could have fallen off during curation or previous study, this is also unlikely to be the cause of the differences seen, at least in this population. Calculus severity does not differ between individuals examined immediately after excavation and those that had been previously excavated and curated.

Table 9.1: Significant differences in dietary indicators between sexes at Hierakonpolis.

DIETARY INDICATOR	DIFFERENCES	AGES	GREATER EXPRESSION
Carious Lesions	None		
Calculus	Upper Anterior	18-35 only	Males
	Upper Posterior	35-50 50+	Males Females
Abscess	None		
Periodontitis	Amount of root exposure	All ages combined	Males
AMTL	None		
Hypoplastic Defect	None		
Macrowear	Upper M1	All ages combined	Males
	Lower M1	All ages	Males
	Upper M2	All ages combined	Males
Microwear	None		

Another possible activity that could remove calculus from the maxillary teeth of females is flute playing. Numerous dynastic carvings depict girls and women playing these and other musical instruments. It is stressed that only young females played musical instruments (Casson, 1975; Robins, 1997; Westendorf, 1968), which could explain why the amount of calculus increases when women reach the age of 50. While commonly referred to as a flute, this instrument was quite different than the modern counterpart played in western societies. Ancient Egyptian flutes consisted of one or two mouth pieces made of hollowed reeds (Brier and Hobbs, 1999; Casson, 1975). One end of each reed appears to have been inserted into the mouth, one on either side, against the teeth (see Figure 9.1). Some form of this flute probably existed in the Predynastic and could have acted to rub the calculus off of the teeth with which it came into contact. However, it may not be realistic that all females at Hierakonpolis played the flute and often enough to have such a significant impact on calculus deposition.

Figure 9.1: Female flute player. Redrawn from photograph of the 18th Dynasty tomb chapel of Nebamun at Thebes. Photograph printed in Robins (1997:139).

A more likely explanation is textile production, which is known to have occurred at Hierakonpolis (Friedman, 1999). One step in the process of preparing textiles could have removed calculus from the teeth. There are two known techniques for making thread: spinning and splicing. Spinning involves twisting fibers together in order to make a long, cohesive length of slightly elastic thread. Once the fibers were spun, the flax was wound into balls or coils. Pictures from the tomb of Djehuty-hotep (Figure 9.2) depicting this stage show the woman's hands at her mouth, suggesting she was moistening the fibers. (Crowfoot, 1931:24; Vogelsang-Eastwood, 2000). Egyptian women were still using their mouth to moisten the fibers until comparatively recently at the villages of Nahya and Kurdasseh (Crowfoot, 1931). The frequent rubbing of flax fibers against the teeth would be sufficient to remove calculus. Analysis of textiles from Hierakonpolis confirms that the threads were spun, rather than spliced (Jones, 2001)

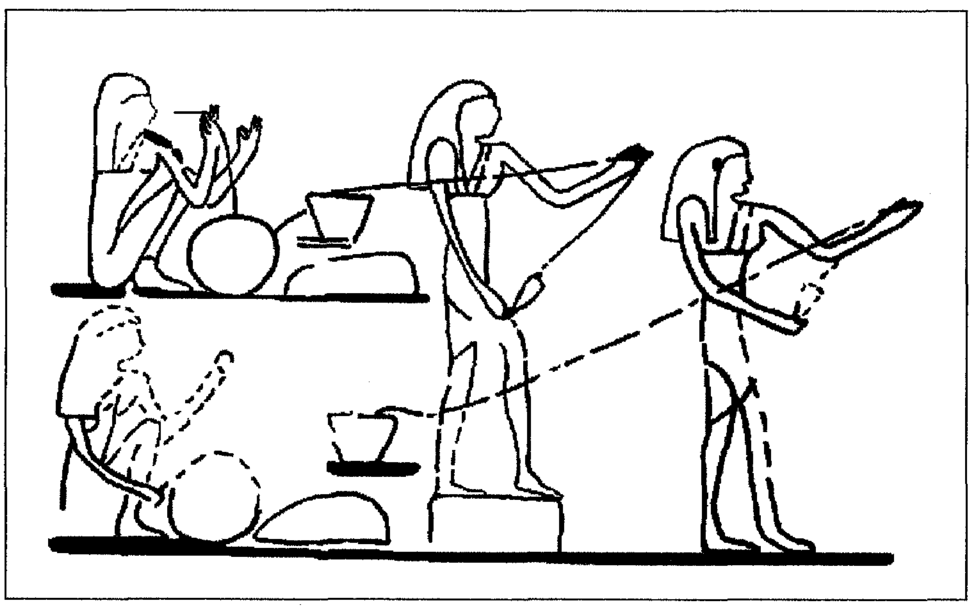

Figure 9.2: Women spinning flax. Redrawn by author from a larger tomb scene in Newberry (1895:Plate XXVI).

Increased root exposure due to periodontal disease among males is most likely due to the greater amount of calculus. As explained in Chapter Four, calculus formation may act to slightly separate the gingiva from the tooth surface (Riethe, 1974). As more calculus forms, there is a greater surface area available to which plaque can adhere, increasing the chance for exposure of the periodontal tissue to plaque bacteria (Neely et al., 2001).

Differences between males and females in the amount of macrowear do appear to be a result of diet. For both males and females, the mean macrowear score for each age group is nearly equal for the maxillary and mandibular molars. Macrowear scores for first and second molars increase steadily with age, with males having a higher wear score in all categories. This suggests that although similar in most other respects, the diet of males contains a slightly higher quantity of abrasive foods than that of the females. It is unlikely that the differences are due to non-dietary abrasion because of the similarity in the degree of macrowear throughout the dental arcade. An occupational related abrasion would most often affect only a few teeth. Patterns of dental abrasion that indicate tool function typically result in wear planes that angle toward each other resulting in a groove in the tooth row (see figure 9.3) (Molnar, 1971). For example, splitting shafts of plants with the teeth for basket making produces a distinctive niche behind the canine, generally on one side (Molnar, 1972).

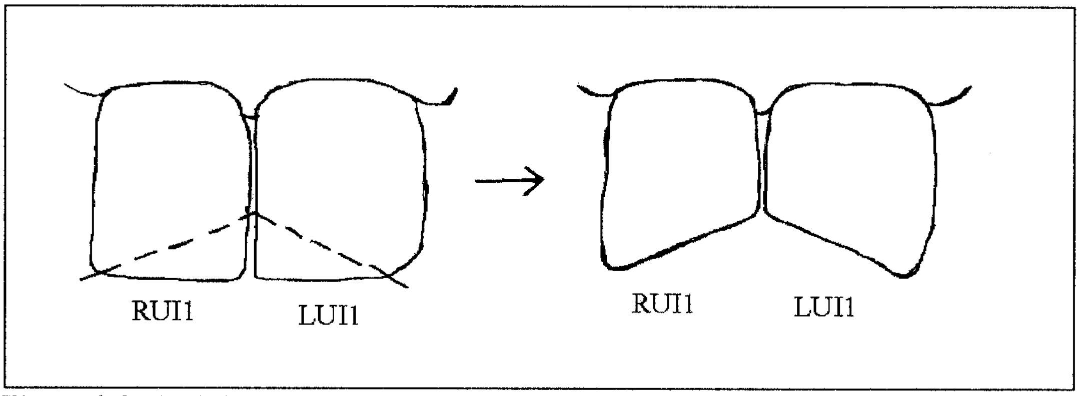

Figure 9.3: Activity-induced wear pattern. Adapted from Molnar, 1971:187.

Although wear angles were not compared quantitatively here, wear on all individuals regardless of age or sex appears to be flat or nearly flat. Wear angles are mentioned here because this pattern is somewhat unusual. In mandibular molars, buccal cusps typically wear at a greater rate than lingual cusps and vice versa for maxillary molars, due to tooth to tooth contact allowed by a soft diet (Hillson, 1986; Osbourn, 1982; Smith, 1986a). The flatter plane of wear is seen almost exclusively among pre-agricultural groups due to consumption of fibrous plant material, which spreads uniformly over the tooth surface during mastication (Smith, 1984). This would suggest that individuals at Hierakonpolis were still fairly reliant upon raw vegetables in their diet.

Because the majority of dietary indicators observed are age dependent, a comparison between juveniles and adults is problematic. Thus, a comparison of juvenile and adult dietary differences can best be examined through microwear, which is discussed below.

Dental Health

Despite the availability of cariogenic foods (see Chapter 2, Table 2.3), less than half of the adult population experienced any carious lesions. Those with caries averaged only two carious teeth per individual. The majority of carious lesions were on occlusal surfaces, suggesting the consumption of refined carbohydrates as they are sticky and are easily trapped in grooves of the enamel surface (Smith, 1986b). Archaeological evidence along with the data from this study suggests that, in this population, bread and raw or cooked vegetables are likely the major sources of carbohydrates.

The abrasiveness of bread and raw vegetable fibers (see below) led to a steady, but relatively slow rate of attrition (diet related macrowear). In turn, the rate of attrition was sufficient to produce a reduced rate of caries. As enamel wears, there are fewer grooves in which sticky foods may become lodged, thereby reducing the risk of bacterial decay (Cran, 1959). Likewise, incipient carious lesions, if they develop slowly enough, may actually be worn away before they can penetrate the enamel surface. That is not to say that attrition was the only factor leading to the low rate of observed caries. Such a low incidence of carious lesions also suggests that at least some protein, either meat, fish or both, was being consumed. Protein consumption alters the Ph of saliva making the oral environment unfavorable for bacterial growth (Hillson, 1979).

The small number and low severity of carious lesions, in turn, helped to keep the number of abscesses low. Within the entire population (196 individuals) only 13 carious lesions led to abscess. The remaining two abscesses resulted from attrition, suggesting that although steady, the overall macrowear rate was not so fast as to regularly lead to pulp exposure. When the primary dentin is exposed, as through attrition, secondary reparative dentin forms. If the primary dentin exposure is slow enough, the secondary reparative dentin is sufficient to protect the pulp cavity from exposure (Kuttler, 1959). Because the pulp cavities in the Hierakonpolis population were rarely exposed, the attrition must have occurred slowly enough such that the formation of secondary dentin was sufficient for protection. Thus, while the diet was abrasive enough to steadily wear the teeth, it must have been sufficiently soft for the wear to occur slowly.

The relatively low occurrence of antemortem tooth loss attests to the ability of the secondary dentin to protect the roots as well as to the low incidence of caries and periodontal disease. Less than 10% of individuals under 35 years experienced any antemortem tooth loss. As expected, the number of affected individuals increases with age, but remains under 20% overall. Less than half of those affected lost more than one tooth and no one was completely edentulous.

Dietary Inferences

The expression of some of the dietary indicators studied here, such as calculus and periodontal disease, are suggested to result in part from non-dietary causes within this population. Others, such as caries, abscess and antemortem tooth loss, are at least somewhat dependent upon wear. Therefore, although all indicators provided useful information about the sample, macrowear and microwear when considered with caries are the most efficient indicators of diet in the Hierakonpolis sample. Thus, in response to the broader research question regarding the best combination of dietary indicators, information was gleaned from all indicators studied, even though not all referred to diet. This distinction is discussed in greater detail below.

In general, a low incidence of small carious lesions, steady attrition, few microwear features, a low density of large (> 4 microns) pits, wide scratches with poorly defined margins and a high degree of polish characterize the working class of Hierakonpolis. The low number of microwear features and low pit density suggests a mild crushing diet (Molleson et al., 1993), with few hard items (low pit density) although those present required a great amount of crushing (large pits). The most likely source of these hard items is from inclusions in the bread.

There are numerous examples of archaeological evidence to suggest the consumption of bread by Predynastic Egyptians. The process of bread manufacture is represented in Dynastic tomb decorations (Morcos and Morcos, 1977; Ruffer, 1919). The majority of information on bread is derived from bread remains in Predynastic graves (Samuel, 2000), which include loaves of bread made from wheat, barley, or millet, and sometimes including lotus seeds, colocasia rhizome, or dum palm dates (Morcos and Morcos, 1977; Ruffer, 1919). Without bread from settlements, it is not possible to know if these loaves are the same as was consumed in daily life without analysis of the human remains. Gut contents from the working class cemetery at Hierakonpolis also show evidence of bread, with the main ingredient being emmer wheat (Fahmy, 2000). Gut contents and loaves found in the graves reveal that the bread contained small mineral fragments and a high degree of chaff (Fahmy, 2000; Leek, 1972), and it is likely that bread loaves made for consumption by the living also contained these impurities. Also, controlling for wind-blown sand and contamination from stones used to grind the grain would have been difficult (Leek, 1972). The small mineral fragments and chaff in the bread could be responsible for the steady rate of macrowear and low density of large pit features evident on the micrographs. Thus, this study supports the likelihood that bread, which is a main food item offered to the deceased in the Predynastic (Bruyere, 1937; Friedman, 1999), was also a main food staple for the living at Hierakonpolis.

Other researchers (Blaeuer and Rose, 1982; Moore-Jansen, 1982; Rose and Marks, 1985) have attributed large scratches, like those seen at Hierakonpolis, to the use of stone grinding implements. It is likely that mineral fragments from stone grinding implements, creating large scratches, as well as sand particles and other inclusions such as seeds, creating a low density of large pits, are responsible for the majority of the microwear features seen on the teeth at Hierakonpolis.

That is not to say that bread was the only, or even most important food item consumed. As explained in Chapter Five, the food items that require the most chewing leave the dominant impressions on the teeth. In the case of the working class at Hierakonpolis, the most likely candidate is raw vegetables, evidenced by the steady attrition rate and high degree of polish (Harmon and Rose, 1988; Marks et al., 1985). Note that while inclusions in bread likely created the majority of the microwear features evident on the micrographs, polish is not considered a feature, but rather an absence of features.

A diet fairly high in raw vegetable fibers would have polished away all but the larger microwear features, leaving food items like meats and fruits that produce fine scratches and small pits, respectively, nearly undetectable. Archaeological evidence, such as butchered faunal remains and fishhooks, suggests that both meat and fish were eaten. There is archaeological evidence of domesticated cattle, goats, sheep and pigs (Morcos and Morcos, 1977; Ruffer, 1919), as well as remains of wild geese, ducks (Krzyzaniak, 1988), gazelle, hare, oryx, (Morcos and Morcos, 1977), and Nile perch (Morcos and Morcos, 1977; Ruffer, 1919). Likewise, the low caries rate cannot be entirely explained by attrition, and in turn, this suggests there was a considerable amount of protein in the diet (Hillson, 1979). Thus, while the question of which specific flora and fauna were being consumed cannot be answered, this study suggests that cultivated grasses (emmer wheat), raw vegetables, and probably meats and fish were being eaten by the working class at Hierakonpolis.

The permanent dentition of all juveniles exhibits polish, which is significantly different than adults. Other microwear features do not differ, however, suggesting that other than the polish producing vegetable fiber, juveniles diets were similar to that of the adults. For example, while only some adults were eating raw vegetables, apparently all of the children were. Of the edible flora available in Egypt during the Predynastic period, the foods most likely to polish the teeth are raw rhizomes or tubers of water lily, yellow nutsedge, reed, club-rush, and turnip and possibly the raw leaves of water lettuce or wattle. From this list, the most likely candidate may be yellow nutsedge (*Cyperus esculentus*), of which the tubers are known today as tiger nuts. *Cyperus esculentus* was found in a basket of a Predynastic burial at Hierakonpolis (Friedman, 1994). Tubers of *Cyperus esculentus* have a sweet taste, and contain water and oils along with the fiber necessary to produce polish. They would have offered a high calorie content, pleasant taste, and provided water. The weedy form of *Cyperus esculentus* grows readily among horticultural crops and was later cultivated by Egyptians (Negbi, 1992). Tubers of the *Cyperus esculentus* may have served as a refreshing treat for children, crop workers, or anyone else passing by the plant. If this tuber were consumed, as suggested, the higher degree of wear among males would imply that males were eating it more frequently than females. Frequent consumption of *Cyperus esculentus*, or other fibrous plant, in addition to leaving a polish on the tooth, would also explain the flat wear plane seen in this population. Thus, while they were most likely consuming bread, which would typically lead to an angled macrowear plane, the daily consumption of raw vegetable fibers would be adequate to level the wear to a flat plane.

A juvenile diet similar to that of the adults is also supported by data on hypoplastic defects. Less than half of the individuals that reached adulthood suffered from hypoplastic events. The majority of those defects were experienced before the age of four and were most likely due to the psychological and nutritional trauma of weaning (Hillson, 1979). The remaining individuals tended to suffer only one acute hypoplastic episode, which implies there was no long-term starvation or other chronic stress. Similar microwear patterns suggest that juveniles were eating the same types of food as adults, and the hypoplastic data suggests that they were receiving enough of that food to remain relatively healthy during childhood.

Diet and Dental Health at Naqada

Table 9.2 shows that few differences exist between the sexes, but that when differences do occur, females at Naqada always have the greater expression of the dietary indicator. Females over 50 years of age have more carious lesions than males in the same age group; however, this is more likely related to smaller sample size than diet. There were five males and six females over the age of 50 available for study. At these levels, the slightly higher percentage of females with carious lesions resulted in significantly more teeth with carious lesions among females.

Table 9.2: Significant differences in dietary indicators between sexes at Naqada.

DIETARY INDICATOR	DIFFERENCES	AGES	GREATER EXPRESSION
Carious Lesions	Tooth count	50+	Females
Calculus	None		
Abscess	None		
Periodontitis	None		
AMTL	None		
Hypoplastic Defect	None		
Macrowear	None		
Microwear	Polish	All adult ages combined	Females

Differences in the number of males and females with polish do appear to be a result of diet. Significantly more females than males exhibit polish. Twenty percent of males in all age categories exhibit polish. While the number of females varies somewhat, around 50% in each age category exhibits polish. The exception for both males and females is the 50+ year age group. Only one male and one female could be examined and neither showed polish, which may be a result of the severe macrowear, which makes the enamel prisms less likely to stand out.

The majority of dietary indicators observed in this study are age dependent, which makes comparison between juveniles and adults problematic. Because microwear is not age dependent, it is used to examine dietary differences between juveniles and adults, as discussed below.

Dental Health

Despite the availability of cariogenic foods (see Chapter 2, Table 2.3), less than half of the adult sample at Naqada experienced any carious lesions. Those individuals with caries averaged only 1.8 carious teeth per mouth. Overall, less than half of the carious lesions were located on the occlusal surface, suggesting a diet higher in meat or other proteins and lower in refined carbohydrates, as meats commonly become lodged around the gum-line (Smith, 1986b). However, non-occlusal lesions may be disproportionately high. When wear-related carious lesions are removed, well over half of the remaining lesions are on occlusal surfaces, suggesting the diet did indeed contain many refined carbohydrates. The overall low incidence of caries suggests at least some protein in the diet (Hillson, 1979).

A number of individuals at Naqada, both male and female, showed what resembled 'toothpick wear' between the mandibular canine and first premolar or mandibular first and second premolar (see Figure 9.4). In many cases, this wear led to dentin exposure and subsequently carious lesions. None of the carious lesions appear to have occurred before the 'toothpick wear' was formed, nor were there any other pathologies associated with those teeth that would cause pain. Toothpick wear, which is not seen at Hierakonpolis, may be related to oral hygiene, an occupational task such as stripping reeds, or a behavior such as holding a stalk of grass between the teeth.

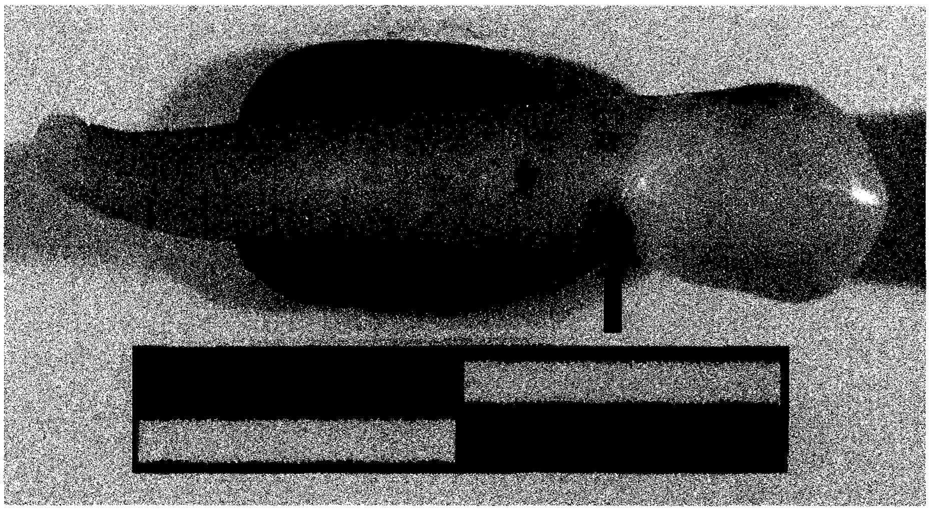

Figure 9.4: Toothpick wear. Arrow points to 'toothpick' wear on mesial side of a lower right first premolar.

As at Hierakonpolis, the overall low incidence of carious lesions is more a reflection of the steady rate of attrition, nature of the carbohydrates eaten, and inclusion of protein, rather than complete lack of cariogenic foods. In turn, the low number of carious lesions led to a relatively low number of abscesses. Only 19 of the 30 abscesses seen among the adult sample were a result of carious lesions. The remaining 11 abscesses were related to macrowear, suggesting the rate of attrition was not always slow enough to allow secondary dentin repair. This is supported by the degree of antemortem tooth loss

(AMTL). Only two of the thirteen individuals over 50 did not experience AMTL. Over half of those that showed AMTL lost more than one tooth.

Clearly not all AMTL in the Naqada sample can be attributed to macrowear. Severe carious lesions can also lead to AMTL, as can periodontal disease. However, like caries, periodontal disease is infrequent in this population. Less than five percent of all teeth were affected by periodontal disease, suggesting that the majority of AMTL in the Naqada sample is related to attrition. Both the rate of macrowear and AMTL is greater in the Naqada sample than the Hierakonpolis sample. This would suggest that the diet at Hierakonpolis was softer than that at Naqada. The diet at Hierakonpolis allowed for a rate of wear slow enough for secondary dentin to protect the pulp cavities, resulting in fewer teeth lost antemortem. The diet at Naqada was slightly more abrasive creating a faster rate of wear that resulted in more teeth being lost antemortem due to pulp cavity exposure.

While it is not possible to determine the exact reasons for the faster macrowear rates at Naqada, there are a few factors that could have attributed to a more abrasive diet. Individuals at Naqada may have consumed different proportions of the same foods as those at Hierakonpolis. For example, the rate of macrowear and AMTL could be explained if people at Naqada relied more heavily on bread than meat or cooked vegetables, while Hierakonpolis consumed more meat or cooked vegetables than bread. It is clear that bread contained a great deal of abrasive particles, both from the ingredients and preparation techniques, which could cause the teeth to wear more rapidly (Fahmy, 2000, 2003b, 2004; Leek, 1972). It is also possible that the two populations had different food preparation techniques. Perhaps individuals at Hierakonpolis removed more of the chaff before baking bread, the two groups used different inclusions, or sand (Leek, 1972) was added by individuals at Naqada and not properly removed. In either case, there are dietary differences between the two populations.

Dietary Inferences

Despite the overall low occurrence of carious lesions, the location of the lesions indicates consumption of refined carbohydrates. Calculus severity however, suggests that these carbohydrates were not especially 'sticky'. Bread made from barley fits these criteria. Ground flours baked into breads would have some cariogenic properties but not be as likely to stick to the teeth as, for example, ground maize seen in prehistoric Native American populations (Smith, 1986b). A high sugar content in wine may have also led to the development of carious lesions without producing much calculus. However, it should be noted that the Naqada sample is over 100 years old and some of the calculus could have been lost in the handling of the remains.

Some of the dietary indicators studied here, such as abscess and antemortem tooth loss, are dependent on caries and macrowear. Thus, although all indicators provided useful information about this sample, the most efficient indicators for diet in the Naqada sample are caries and calculus in conjunction with macrowear and microwear. As for the broader research question regarding the best combination of dietary indicators, a different combination provided the most information about diet than at Hierakonpolis. This difference is discussed in more detail below.

In general, a steady, fairly rapid rate of attrition, few microwear features, a low density of large (> 4 microns) pits, wide scratches with poorly defined margins, and a relatively low degree of polish characterizes the Naqada population. The low number of microwear features and low pit density suggests a mild crushing diet (Molleson et al., 1993). There was not a great quantity of hard items in the diet (low pit density) but those present required a great amount of crushing (large pits). The most likely source of these hard items is from bread. Other researchers (Blaeuer and Rose, 1982; Moore-Jansen, 1982; Rose and Marks, 1985) have attributed large scratches, like those seen at Naqada and Hierakonpolis, to the use of stone grinding implements. It is likely that bread consumption is responsible for the majority of microwear features seen on the teeth of this sample. Mineral fragments from stone grinding implements created large scratches, while sand particles or other inclusions such as seeds created a low density of large pits. As was the case at Hierakonpolis, the Naqada sample also suggests the likelihood that bread, a major food offering for the deceased (Bruyere, 1937; Friedman, 1999), was also consumed by the living.

It should be noted that bread was not the only, and possibly not the most important, food item consumed. Food items that require the most chewing leave the dominant impressions on the teeth. For some individuals at Naqada the dominant impression on the teeth was polish, probably caused by eating raw vegetables. However, pit and scratch width and pit percentage on unpolished areas of the micrographs do not differ significantly from micrographs of individuals without polish. Thus, it appears that bread left the dominant impression on many teeth, erased only by raw vegetable fiber.

Where chewing raw vegetables would polish away most other microwear features, hard inclusions in the bread would leave larger microwear features, covering or obliterating the smaller features that leafy vegetables or meat would leave. Archaeological evidence suggests that meats such as domesticated cattle, goats, sheep and pigs and wild gazelle, hare, oryx, and Nile Perch were eaten (Krzyzaniak, 1988; Morcos and Morcos, 1977; Ruffer, 1919). Low incidence of carious lesions supports the consumption of at least some protein (Hillson, 1979). While the question of which of the available flora and fauna that were eaten cannot be addressed specifically for each item, this study supports the possibility that cultivated foods, such as wheat, barley and millet, some raw vegetables, and meats/fish were being eaten by the working class people at Naqada.

The list of available vegetable foods that could have caused polish is the same as that for Hierakonpolis: raw rhizomes or tubers of water lily, yellow nutsedge, reed, club-rush, or turnip and possibly the raw leaves of water lettuce or wattle. At Naqada, it appears that polish-producing raw vegetables were consumed almost exclusively by females. Males and juveniles showed little signs of eating raw vegetables. No juveniles in the 6-12 year age category exhibited polish, while 60% of those in the 12-18 year age group did. Since few males but all females show polish, for individuals at Naqada that are too young for sex to be determined osteologically, the presence or absence of polish may aid in determining sex.

As at Hierakonpolis, molars at Naqada are worn relatively flat, with only slight instances of an angle. The microwear indicates that individuals at Naqada were not eating as much raw vegetable products as those at Hierakonpolis. However, a constant addition of small quantities of supplemental food to dietary intake can induce considerable wear pattern changes (Molnar, 1972:514). Wear angles in conjunction with polish suggest that all members of the Naqada sample were consuming some raw vegetable product, only in different quantities. For males, the raw vegetable product was most likely an occasional, supplementary food. It was eaten frequently enough to create a somewhat flat wear plane, but a steady consumption of bread or other abrasive foods would have removed evidence of polish on most males. As microwear features are replaced quickly, they would only have to go a matter of days without consuming the raw fibrous plant material in order for signs of polish to be removed. Females almost all exhibited polish along with a flat plane of wear, suggesting that the raw vegetable material was being chewed daily.

Other microwear features do not differ significantly between juveniles and adults, suggesting that other than the item responsible for polish, juveniles and adults shared a similar diet. Hypoplastic defect data suggest that juveniles received enough food to stay relatively healthy. Fewer than 30% of adults suffered from hypoplastic events during childhood. A third experienced the hypoplastic event before age four, possibly due to weaning (Hillson, 1979). Of the remaining individuals, most suffered only one acute hypoplastic episode, which argues against long-term starvation or other chronic stress.

Diet and Dental Health: Hierakonpolis vs. Naqada

Table 9.3 shows that there are at least some differences between individuals at Hierakonpolis and Naqada for every dietary indicator studied. When differences do occur between the samples, Naqada typically shows the greater expression for all of the dental diseases examined. However, Hierakonpolis shows greater expression of calculus, hypoplastic defects, and microwear polish. Differences tend to occur most frequently between females at the two sites. Juveniles at Hierakonpolis and Naqada differ only in the number of individuals exhibiting polish. The indicators studied here have revealed both dietary and non-dietary behavioral differences between the two samples studied. Both are discussed below.

Table 9.3: Significant differences between Hierakonpolis and Naqada.

DIETARY INDICATOR	DIFFERENCES	SEX/AGES	GREATER EXPRESSION
Carious Lesions	Tooth Count	Males: all ages comb. Females: all ages comb.	Naqada Naqada
	Severity	Females: all ages comb.	Naqada
Calculus	Upper Posterior	Females: 50+	Hierakonpolis
Abscess	Individual Count	Females: all ages comb.	Naqada
Periodontitis	Individual Count	Females: all ages comb.	Naqada
	Type	Males: all ages comb. Females: all ages comb.	Hierakonpolis =horizontal
	Root Exposure	Females: all ages comb.	Naqada
	Surface of Bone Loss	Females: all ages comb.	Naqada
AMTL	Individual Count	Males: all ages comb. Females: all ages comb.	Naqada Naqada
	Tooth Count	all individuals comb.	Naqada
Hypoplastic Defect	Individual Count	Males: all ages comb. Females: all ages comb. Juveniles: 12-18	Hierakonpolis Hierakonpolis Hierakonpolis
	Severity	Males: all ages comb.	Naqada
	Age of Occurrence	Males: all ages comb.	NQ= >4
Macrowear	Lower M1	Females: all ages comb.	Naqada
	Lower M2	Females: all ages comb.	Naqada
Microwear	Polish	Males: all ages comb. Juveniles: all ages comb.	Hierakonpolis Hierakonpolis
	Number of Prisms	all individuals comb.	Hierakonpolis

Both males and females at Naqada had more carious teeth than those at Hierakonpolis (see Figure 9.5). This cannot be a product of sample size as more teeth overall were examined at Hierakonpolis. Nor can this be a result of the rate of attrition, as the teeth at Naqada tended to wear at a slightly higher rate than at Hierakonpolis. The slightly faster rate of wear at Naqada could explain why the percentage of males at Hierakonpolis with carious lesions increases with age, while the percentage of males at Naqada with carious lesions decreases with age. Older males at Naqada experienced more wear, which have acted to remove incipient carious lesions. The higher amount of AMTL at Naqada may also mean that older males lost carious or potentially carious teeth; however, the caries correction factor should resolve this bias.

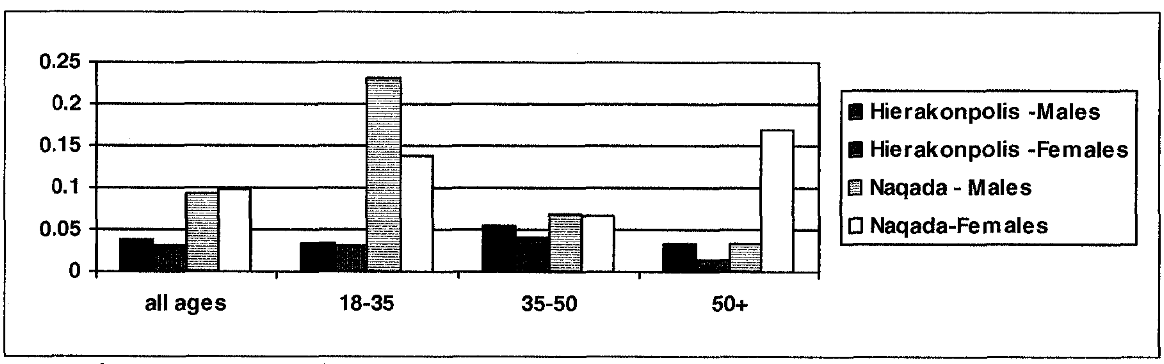

Figure 9.5: Percentage of carious teeth at Hierakonpolis and Naqada.

Females at Naqada had significantly larger carious lesions than females at Hierakonpolis. This could be explained in part by the higher sugar content of barley and wine at Naqada compared to emmer wheat and bouza at Hierakonpolis. Quid chewing by the females at Naqada may have also supplied a constant food source for the bacteria leading to larger carious lesions. With a greater number and severity of carious lesions, it is not surprising that more females at Naqada expressed abscesses than females at Hierakonpolis. This suggests that the diet at Naqada, at least among females, contained either stickier carbohydrates or more sucrose. Also, if females at Naqada were keeping carbohydrate laden food or plant material in their mouths for a long period, a greater number of severe carious lesions would be expected. Thus, caries data suggests that the vegetable-based portion of the diet was different between females from the two samples, which supports the interpretation of the microwear data that different vegetables were responsible for polish at Hierakonpolis and Naqada.

An assessment of calculus severity suggests that young women at Hierakonpolis may have been performing some task that removes calculus from their maxillary dentition. As discussed above, this task may be related to oral hygiene, flute playing, flax spinning techniques, or some other unidentified behavior. The ends of a double headed reed flute inserted into the mouth could have rubbed calculus from the teeth, as could running flax through the mouth to moisten it before spinning. Whatever the task, it does not appear to be practiced by men or by women over 50 years of age. There is no evidence for such an occurrence at Naqada. There is no difference in calculus severity between males and females or between the maxillary and mandibular dentitions of the women at Naqada. Thus, calculus severity suggests a possible behavioral difference between the working class women at Hierakonpolis and Naqada. It may be that women at Hierakonpolis had better oral hygiene, that women at Hierakonpolis played a flute similar to those depicted in the Dynastic period but women at Naqada did not, or that women at the two sites used different techniques for spinning flax. This difference speaks to the question about how culturally similar Hierakonpolis and Naqada were.

Significantly more females at Naqada suffered from periodontal disease than females at Hierakonpolis (see Figure 9.6). Calculus severity did not lead to differences in periodontitis, as the degree of calculus is nearly equal for males and females under 50 years of age for both samples. Both males and females at Hierakonpolis were more likely to suffer from horizontal, or generalized periodontal disease, while individuals at Naqada were more likely to suffer from vertical periodontal disease, or pockets of bone loss. Females at Naqada with periodontal disease suffered more severely than females at Hierakonpolis, regardless of the type of bone loss.

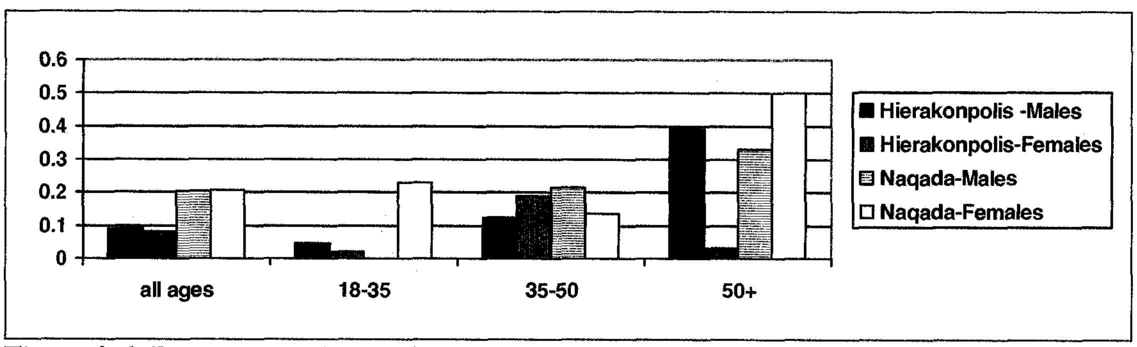

Figure 9.6: Percentage of periodontal disease at Hierakonpolis and Naqada.

The greater expression of periodontal disease and greater number of carious teeth, along with a faster rate of macrowear, led to more antemortem tooth loss at Naqada (see Figure 9.7). A higher percentage of individuals, both male and female, experienced AMTL at Naqada than at Hierakonpolis. There were also a greater number of teeth lost per individual in all categories at Naqada.

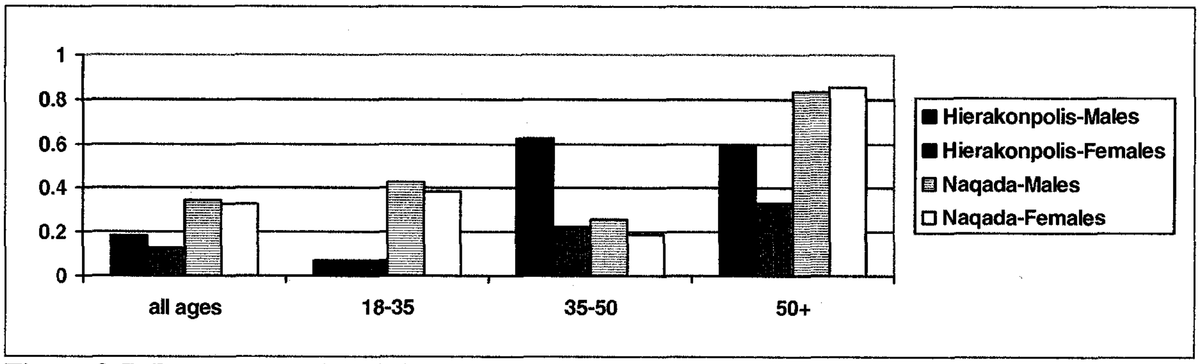

Figure 9.7: Percentage of individuals with AMTL at Hierakonpolis and Naqada.

Hypoplastic defects were the only dental pathology that was experienced by more individuals at Hierakonpolis than at Naqada. This was true of adult males and females as well as juveniles in the 12-17 year age group (see Figure 9.8). Even though fewer males at Naqada exhibited hypoplastic defects, those that did were more likely to suffer from chronic hypoplastic events than at Hierakonpolis. It is more likely that a severe illness, such as fever or gastrointestinal disorder (Goodman and Armelagos, 1985b; Goodman and Rose, 1990; Goodman, 1991) rather than long-term starvation, caused the chronic hypoplastic defects at Naqada. If starvation were responsible, either a greater number of individuals with hypoplastic defects or evidence of seasonal starvation represented by multiple defects on the same individual would be expected.

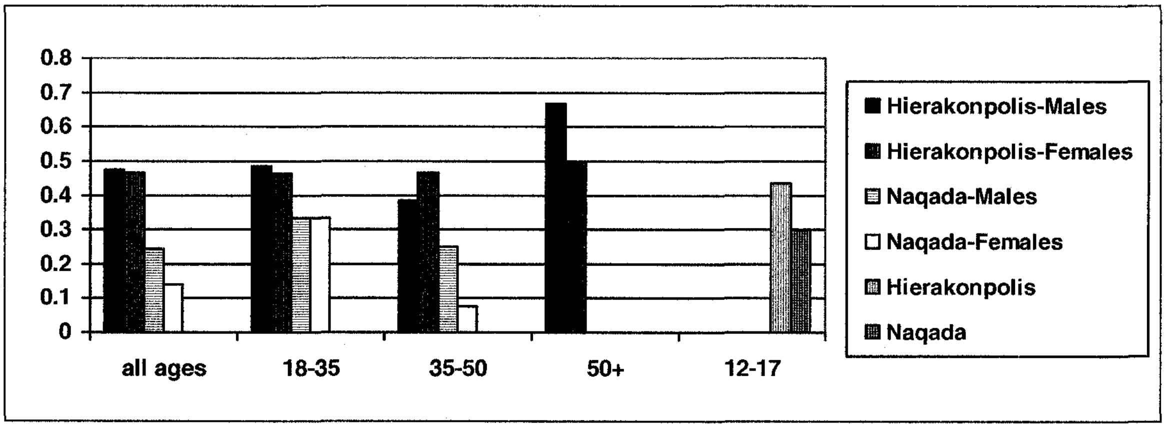

Figure 9.8: Percentage of individuals with hypoplastic defect.

More males at Naqada experienced hypoplastic events after the age of four than males at Hierakonpolis. Less than 40% of hypoplastic defects among males at Hierakonpolis occurred after the age of four, and only one individual experienced a chronic episode after four years of age. Over 60% of hypoplastic defects among males at Naqada occurred after the age of four, with nearly 75% of the chronic episodes occurring after age four. The age at which the hypoplastic defects occurred suggest that those at Hierakonpolis may have been due to the stresses of weaning (Hillson, 1979; see Skinner, 1992 for an argument against weaning causing hypoplastic defects). So many defects occurring after the age of four at Naqada supports the idea of a severe illness, rather than weaning, being responsible for those defects. This may not necessarily imply that more individuals at Naqada suffered from an illness, but that those at Hierakonpolis may not have survived to show hypoplastic defects.

While wear scores for maxillary and mandibular molars are greater among females at Naqada, only the mandibular molars were different enough from those of females at Hierakonpolis to be significant (see Figure 9.9). Although females at Naqada have significantly more macrowear than females at Hierakonpolis on the mandibular first and second molars, wear scores for mandibular and maxillary molars are highly correlated (r = 0.664 - 0.872) in both samples. Thus, there are no significant differences in the wear score for the corresponding maxillary and mandibular molars of females, which is as expected as teeth tend to function as a unit rather than individually (Molnar, 1971). Differences between females in the two samples in mandibular macrowear scores indicate that females at Naqada had a higher rate of macrowear overall, and suggest that the maxillary molars would likely show significant differences with larger sample sizes. The higher rate of macrowear among females at Naqada is most likely due to abrasive food qualities, as the rate of macrowear is comparable among all teeth in an arcade. This pattern suggests that they were not regularly using their teeth as tools and that all wear seen can be attributed to mastication. Thus, the diet among females at Naqada had a slightly more abrasive quality than that among females at Hierakonpolis.

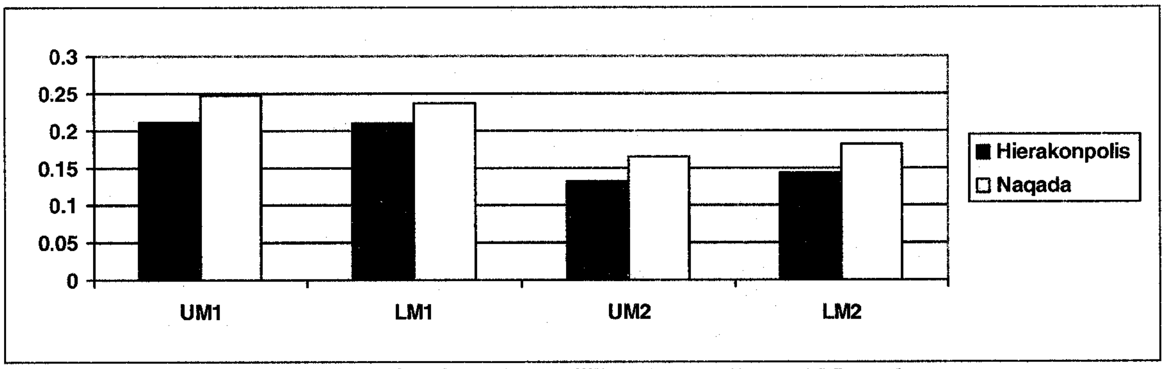

Figure 9.9: Mean wear scores for females at Hierakonpolis and Naqada.

Dietary Inferences

The number of individuals with polish, as illustrated on the micrographs, indicates the greatest dietary difference between the two samples. At Hierakonpolis, all juveniles and nearly equal numbers of males and females exhibit polish. At Naqada, polish is seen almost exclusively on females. While females in both samples are equally likely to have polished enamel, Hierakonpolis has significantly more males and juveniles with polish than Naqada.

Among individuals that have polish, individuals at Hierakonpolis (of all age and sex groups) have more visible enamel prisms per micrograph than those at Naqada. These data suggest that a different, slightly less fibrous food item is responsible for polish at Naqada. Likewise, some difference in family economy or social relations may have existed at Naqada, that is not present at Hierakonpolis, that provides this item to only certain portions of the population.

Burial evidence suggests that these possible differences in family economy or social relations were not due to wealth; as there are no significant differences in the number of grave goods between males and females (Castillos, 1982). Thus, there must have been some other force driving the dietary difference between males and females. Although unsubstantiated, one possibility for the polish seen primarily on the dentition of females and juveniles age 12-17 could be from a medicinal plant that needed to be masticated before being administered. If women were the primary caregivers for the family unit, it is possible that they were chewing the plant often enough to create a visible polish on the teeth. This behavior has been documented in other populations, such as the

Coahuilla Indians of Southern California (Barrows, 1967). If this is the case, the polish that occurs on the teeth of the small percentage of men could be from instances when no women were available to prepare the medicine or from a different type of plant.

The polish may also come from chewing stalks or rhizomes of plants as a 'quid', which may have seemed undesirable for men or small children. The chewing of quids has been documented in numerous places as a way to relieve stress or remove whatever nutrients the otherwise indigestible plant may contain (Gillmore, 1911; Ko et al., 1992; Turner, 1967) and has been suggested for Dynastic Egyptians (Palichuk, 1994). Chewing of a quid by females at Naqada could explain why they exhibit more macrowear and fewer visible enamel prisms than females at Hierakonpolis; however, both quid chewing and raw vegetable consumption would produce the flat wear angles seen among both samples. The caries data could also be explained by quid chewing. Females at Naqada have a greater number of carious lesions and more severe lesions than those at Hierakonpolis. Keeping a carbohydrate rich plant in the mouth for long periods of time, as would be the case with a quid, would likely lead to a greater number of and/or more severe carious lesions.

A high degree of polish exhibited by all age and sex categories and a lower rate of caries at Hierakonpolis suggests that the polish was created by a dietary item, leaving the *Cyperus esculentus* discussed above as one possible explanation for the polish. However, the differential expression of polish and carious lesions at Naqada suggests that the item creating the polish may not have been a part of the diet. Thus, males and children at Naqada were not eating at least one food item, possibly *Cyperus esculentus*, that is fairly important to the diet of males and children at Hierakonpolis. Females at Naqada were possibly practicing either medicinal or recreational chewing of plant material that did not occur at Hierakonpolis.

There is no evidence to suggest that the remainder of the diet differed between the two samples. Macrowear and microwear suggests that individuals of all age and sex groups in both samples were eating bread that may have been prepared in similar fashions. It is impossible, however, to determine from the dentition whether the main grain used for bread (wheat, barley, or millet) or inclusions within the bread (lotus seeds, colocasia rhizome or dum palm dates) varied between the samples. While gut contents of the Hierakonpolis burials suggest that emmer wheat was the main grain (Fahmy, 2000), similar studies may not be possible at Naqada unless previously undisturbed burials are found there.

Evidence for bread consumption by individuals of both samples suggests that the bread consumed by the living was the same style of bread offered to the deceased in burials. While there is no direct evidence for consumption of some other food items used as grave offerings, such as beer (Friedman, 1999) and smoked meat and fish (Bruyere, 1937), it may be inferred that these too were consumed by the living. Likewise, it is possible that items found in tombs as clay representations, such as garlic (Shaw, 1976), may have been considered too valuable to the living. However, actual garlic was found in one Predynastic burial at Hierakonpolis.

Examination of Research Questions

Although generally examined above, each research question warrants its own discussion. (1) What combination of dietary indicators is the most beneficial for establishing an overall picture of diet and dental health? (2) Of the known edible flora and fauna of Predynastic Egypt, what were the working class Egyptians eating. (3) Were the working class Predynastic Egyptians consuming the same food items that are found as burial offerings. (4) Did the working class inhabitants of Hierakonpolis and Naqada consume similar or different diets?

Best Combination of Dietary Indicators

As shown here, the examination of multiple indicators is necessary as some indicators speak more to cultural rather than dietary practices provided valuable information about the different populations. Carious lesion, rate of macrowear, and microwear features helped to reconstruct portions of the diet of each sample. Rates of antemortem tooth loss reinforce data from caries and attrition. Calculus severity played a lesser role in dietary reconstruction for these populations but revealed interesting behavioral differences that would have otherwise been overlooked. Hypoplastic enamel defects likewise played a minor role in reconstruction of diet, but exposed possible differences in the treatment of children at the two sites. Abscess, periodontitis and antemortem tooth loss show that there is little difference in dental health between the two samples, which is not surprising given the similarities in diet.

What Were the Predynastic Working Class Eating?

The second and third research questions, i.e., which of the available foods were being eaten and were food offerings in burials being eaten, can be largely examined together. These questions were addressed extensively in Chapters Eight and Nine. To summarize, dental indicators confirm that all members of the Predynastic working class at Hierakonpolis and Naqada were eating bread made of wheat, barley, or millet. All portions of the working class at Hierakonpolis were eating a raw vegetable, possibly *Cyperus esculentus*. Adult females at Naqada were eating or chewing some raw vegetable, possibly plant stalks or rhizomes, different than that eaten at Hierakonpolis. At Naqada very few men or children were eating this vegetable. It is likely that meat and other cooked vegetables were being consumed at both sites, however, the bread and raw vegetables left the predominant impressions on the teeth, masking any other food types.

Comparison of Hierakonpolis and Naqada

An examination of diet of the two samples revealed more behavioral differences than strict dietary differences. Considering the proximity of the two sites and presumed equality of available food resources, the similarities in diet between the working classes of Hierakonpolis and Naqada are not as striking as the differences in behavior. It is not unexpected that two groups, given the same choices of edible flora and fauna, would utilize similar food items. Nor do comparable preparation techniques and reliance on bread seem extraordinary given the location of the sites and the trade network along the Nile (see for example, Adams and Friedman, 1992; Adams, 1996b; Bard, 1996; Holmes, 1989a, 1996; Mark, 1998). This trade network has been shown to be quite widespread with participation even by relatively small farming villages (Bard, 1996). Most Predynastic Upper Egyptian sites contain materials from the Eastern Desert (Lucas and Harris, 1989) and many contain shells from the Red Sea (Bard, 1996). There is also evidence of trade with Nubia to the south and other foreign contacts in the north (Friedman, 1994).

Trade and integration of certain material items can and often does exist without acculturation of either population (Berry, 2003; Olmedo, 1980). Within North America, there are instances of trade of lithic material between culturally distinct groups (Earl and Erickson, 1982; Prentiss and Kuijt, 2004). Despite the obvious trade of material culture (Friedman, 1994, 2000; Holmes, 1988, 1989b, 1996) and technology, this study suggests, at least as related to dietary intake, that the two urban centers of Hierakonpolis and Naqada remained, were culturally dissimilar during the Predynastic period.

The discovery of behavioral dietary differences between these two populations has implications for the political, economic and interpersonal interactions of the inhabitants of Hierakonpolis and Naqada. The data have shown that: (1) the children of Hierakonpolis were generally healthier than the children of Naqada, (2) the women of Hierakonpolis were performing some task, be it oral hygiene, flute playing, or flax spinning technique that was not performed by the women of Naqada, (3) the women of Naqada were likely chewing some plant material, either as a quid or perhaps for medicinal purposes, among others, that the women of Hierakonpolis were not chewing, and (4) that the men and children were apparently eating a vegetable, possibly *Cyperus* *esculentus*, that the men and children of Naqada were not eating. This evidence suggests at least some different cultural practices between the working class inhabitants of these two sites. Evidence of behavioral dissimilarities found in this study in conjunction with other indicators (Adams, 1988; Bard, 1987b; Finkenstaedt, 1979; Panofski, 1962) supports the notion that the working class populations of Hierakonpolis and Naqada remained separate social, political and/or cultural entities (Friedman, 1994; Holmes, 1989a).

CHAPTER TEN

SUMMARY AND CONCLUSIONS

In this dissertation an array of dietary indicators on the dentitions of working class samples from Predynastic Hierakonpolis and Naqada were examined. Both Hierakonpolis and Naqada were large urban centers during the Egyptian Predynastic period (Adams and Cialowicz, 1997; Bard, 1994b; Griswold, 1992; Hassan, 1988b; Kemp, 1989; Midant-Reynes, 2000b; Wilkinson, 1999). Both sites are located on the west bank of the Nile. Hierakonpolis is approximately 100 km south of present day Luxor, while Naqada is approximately 28 km northwest of Luxor.

The teeth of the Hierakonpolis sample comes from the working class cemetery and consists of 196 individuals ranging from six years to over 50 years of age. The burials have been determined to date to Naqada Ic to Naqada IIc (3800 – 3650 BC) with some possibly as late as Naqada IId (3800 – 3300 BC) (Friedman, 1999, 2002). The Naqada sample also comes from the working class and consists of 168 individuals ranging from six years to over 50 years of age. The Naqada burials have been determined to date to Naqada Ic to IIIa (3800 –3300 BC), with the majority of the datable burials dating to Naqada II (Hassan, 1984).

Naqada II, from which the majority of burials used in this study date, was a time of great cultural change. This period is marked by an expansion of the culture northwards toward the Delta and southwards as far as Nubia. Naqada II was also a time of increasing social differentiation and political/economic complexity. These cultural changes are evidenced by the appearance of distinct habitation, burial, ceremonial/administrative, and industrial zones as well as indications of specialized production and differential accumulation of wealth (Bard, 1994a; Geller, 1992a; Midant-Reynes, 2000b).

Seven dental dietary indicators were examined from the Hierakonpolis and Naqada samples including carious lesions, calculus, abscess, periodontal disease, hypoplastic enamel defects, macrowear, and microwear. These dietary indicators were used to explore several broad research questions. (1) What combination of dietary indicators is the most beneficial for establishing an overall picture of diet and dental health? (2) Of the known edible flora and fauna of Predynastic Egypt, what were the working class Egyptians eating? (3) Were the working class Predynastic Egyptians consuming the same food items that are found as burial offerings. (4) What does the presence, or absence, of differences in diet between Hierakonpolis and Naqada imply about the social relationship between the two urban centers?

In order to answer these broad research questions, three working hypotheses were developed for these samples. The working hypotheses tested in this dissertation were: (1) that all members of the working class had equal access to food resources, (2) that the edible plant and animal remains found as burial offerings and in habitation areas were actually being consumed, and (3) that members of the working class from both Hierakonpolis and Naqada maintained similar diets. The first working hypothesis appears to be supported at Hierakonpolis and at Naqada. At Naqada adult females had nearly exclusive access to a certain raw vegetable that produced polish. However, the polish most likely resulted from chewing plant stems or leaves for medicinal or recreational purposes, rather than a strictly dietary differences. Children at Naqada experienced chronic hypoplastic episodes after the age of four, suggesting possible malnutrition or severe illness, with illness being the most likely cause.

The second working hypothesis is at least partially supported. Bread found as burial offerings was in fact being consumed by all members of the working class. While consumption of bread is suggest though archaeological remains, conclusions about daily bread could not necessarily be drawn from funerary bread (Fahmy, 2000). This study suggest that daily bread, at least among the working class, had a similar consistency to funerary bread. Because the abrasiveness of the bread and other raw vegetable fibers acted to erase other microwear features it is impossible to say with certainty that other meats or vegetables found as burial offerings or within habitation areas were being consumed. However, because at least one item left as a burial offering (bread) was an important food item for the living, it may be implied that other food offerings left for the deceased were also eaten in life.

The third hypothesis was also partially supported. Whereas members of the working class from both Hierakonpolis and Naqada consumed bread, it is impossible at this time to say whether the main grains (wheat, barley, or millet) or inclusions were identical at each site or even within the sites. Gut contents suggest that wheat was the main grain, at least at Hierakonpolis (Fahmy, 2000). There were differences between the populations in who was eating raw vegetables and possibly in what raw vegetables were being consumed.

These working hypotheses were then applied to the broader research questions to show that all dietary indicators were important for this study. Even though some indicators did not answer questions directly related to diet, they were still able to show important cultural differences. This study was able to support the consumption of several hypothesized dietary items, such as bread, meats and vegetables. This study also showed that foods contained within burials were similar to those being consumed by the living.

Significance

A number of significant points were gleaned from this study. First, it is important to collect data on as many dental dietary indicators as possible. Some indicators were found to be more useful for dietary information for one sample than the other, and even those indicators that did not prove useful for diet per se revealed behavioral information.

Second, this study illustrates the usefulness of combining archaeological details with biological data. Lists of known flora, fauna and prepared foods from archaeological contexts provided a basis for comparison with biological information about diet. Moreover, data gathered from the dental dietary indicators were able to confirm that some of the foods thought to be consumed based on archaeological evidence were actually eaten.

Finally, the necessity of examining more than one sample, and of treating them as separate samples, is demonstrated by this study. Many of the previous studies on Egyptian diet or dental health combined individuals from several sites in order to increase sample size (e.g., Greene, 1972; Harris and Ponitz, 1980; Leek, 1966, 1969; Turner and Bennet, 1913). These studies have provided the basis for what is known about Egyptian dental pathologies. However, important differences between samples, regions or time periods may have not only been missed but also 'averaged' into one description that doesn't accurately describe any one sample.

Had only one group, either Hierakonpolis or Naqada, been used to determine diet for working class Predynastic Egyptians, differences between the two samples would have never been observed. Diet of the sample studied might have been perceived as the diet for all Predynastic Egyptians. Likewise, if the two groups had been combined, the data would have been entirely different; not actually representing either sample. In this case, as in most anthropological studies, it is those differences that provide the most information.

Future Research

While this study has provided a great deal of information, it is by no means the last word in dietary reconstruction of Predynastic Egyptians, or on the relationship between Hierakonpolis and Naqada. Dental indicators alone cannot provide a complete picture of diet. Future research should also include stable isotope testing, trace-element analysis, and examination of gut contents at each site. Stable isotope analysis could be conducted on the skeletal remains in order to further examine dietary differences. Stable isotopes can distinguish between diets of C_3 and C_4 plants, of meat and fish, or of meat and plants (Bender et al., 1981; Runia, 1987; Schurr, 1992). Stable isotopes could help to verify the consumption of *Cyperus esculentus* as it is a C_4 plant. Trace element analysis also uses skeletal remains along with other remaining tissues to aid in the reconstruction of diet. However, trace elements analysis focuses on minerals rather than organic portions. While the exact meanings of trace element levels are debated (Radosevich, 1993), it may still be a useful aid to dietary reconstruction when used in conjunction with other forms of data. Gut content analysis has already begun at Hierakonpolis (Fahmy, 2003b, 2004) and has proven beneficial for the current study. Continued examination of gut contents should provide a more detailed comparison with dental indicators.

Although sample sizes are much smaller, research is already underway by the author to compare dental indicators of diet among the different social classes. Another avenue of study would be to compare samples from other, smaller sites in Predynastic Upper Egypt to see if their diets are more similar to Hierakonpolis or to Naqada.

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APPENDIX

DATA TABLES

Corrected Carious lesions

Table A.1: Hierakonpolis carious lesions.

	Number of observed teeth	Observed carious teeth	% observed carious teeth	Number of teeth lost antemortem	Corrected caries rate
Males	1128	44	3.9%	28	3.9%
18-35	767	26	3.4%	3	3.4%
35-50	272	15	5.5%	12	5.5%
50+	89	3	3.4%	13	3.4%
Females	176	45	3.1%	24	3.1%
18-35	1034	32	3.1%	6	3.1%
35-50	311	12	3.9%	15	4.0%
50+	131	2	1.5%	3	1.5%
Juveniles	572	2	0.3%	0	0.3%
6-12	170	1	0.6%	0	0.6%
12-17	402	1	0.2%	0	0.2%

Table A.2: Naqada carious lesions.

	Number of observed teeth	Observed carious teeth	% observed carious teeth	Number of teeth lost antemortem	Corrected caries rate
Males	469	49	10.4%	65	14.4%
18-35	81	11	13.6%	12	23.3%
35-50	325	37	11.4%	30	14.4%
50+	63	1	1.6%	23	3.4%
Females	469	28	6.0%	74	9.8%
18-35	104	9	8.7%	14	13.7%
35-50	292	13	4.5%	33	6.6%
50+	73	6	8.2%	27	16.8%
Juveniles	75	1	1.3%	0	1.3%
6-12	14	0	0%	0	0%
12-17	61	1	1.6%	0	1.6%

Calculus Index

Table A.3: Hierakonpolis calculus.

	Upper Anterior		Lower Anterior		Upper Posterior		Lower Posterior	
	min. index	max. index	min. index	max. index	min. index	max. index	min. index	max. index
Males								
18-35	0.000	1.000	0.000	1.333	0.000	1.111	0.000	1.148
35-50	0.000	1.000	0.000	1.000	0.000	1.200	0.000	1.400
50+	0.000	1.000	0.000	1.167	0.056	0.333	0.000	1.000
Females								
18-35	0.000	1.111	0.000	1.500	0.000	1.467	0.000	1.714
35-50	0.000	0.750	0.000	1.222	0.000	1.074	0.000	1.000
50+	0.000	1.333	0.200	1.250	0.500	1.333	0.704	1.048
Juveniles								
6-12	0.000	0.111	0.000	1.133	0.000	0.333	0.000	0.417
12-17	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000

Table A.4: Naqada calculus

	Upper Anterior		Lower Anterior		Upper Posterior		Lower Posterior	
	min. index	max. index	min. index	max. index	min. index	max. index	min. index	max. index
Males								
18-35	0.000	0.000	NA	NA	0.000	0.833	0.133	1.000
35-50	0.333	0.833	0.000	0.000	0.000	1.333	0.000	1.000
50+	0.667	0.667	NA	NA	0.333	1.000	0.000	0.750
Females								
18-35	0.000	1.000	0.333	0.952	0.000	1.000	0.000	0.667
35-50	0.000	1.000	0.000	0.833	0.000	1.167	0.000	1.037
50+	0.000	0.000	NA	NA	0.000	0.667	0.250	1.000
Juveniles								
6-12	NA	NA	NA	NA	0.000	0.111	0.000	0.000
12-17	0.333	0.333	NA	NA	0.000	0.444	0.000	0.833

Abscess

Table A.5: Hierakonpolis Abscess.

	Number of observed teeth	Observed abscessed teeth	% observed abscessed teeth	Mean # of abscesses per ind.
Males	1488	16	1.1%	
18-35	995	3	0.3%	0.10
35-50	348	3	0.9%	0.18
50+	100	10	10.0%	2.00
Females	1659	8	0.5%	
18-35	1180	2	0.2%	0.04
35-50	342	0	0%	0.00
50+	129	6	4.7%	1.00
Juveniles	498	0	0%	0
6-12	180	0	0%	0
12-17	318	0	0%	0

Table A.6: Naqada Abscess.

	Number of observed teeth	Observed abscessed teeth	% observed abscessed teeth	Mean # of abscesses per ind.
Males	1221	27	2.2%	
18-35	160	1	0.6%	
35-50	960	16	1.7%	
50+	101	11	1.1%	
Females	1059	21	2.0%	
18-35	241	11	0.5%	
35-50	687	4	0.6%	
50+	131	6	4.7%	
Juveniles	235	0	0%	
6-12	41	0	0%	
12-17	194	0	0%	

Periodontal Disease

Table A.7: Hierakonpolis periodontal disease.

	Number of observed teeth	Number of teeth with vertical	Number of teeth with horizontal	Percent total teeth affected	Percent affected individuals
Males	1457	8	3	0.8%	12.7%
18-35	998	0	2	0.2%	7.1%
35-50	350	3	1	1.1%	12.5%
50+	109	5	0	0.5%	60.0%
Females	1655	9	4	0.8%	6.8
18-35	1180	2	0	0.2%	3.8%
35-50	340	3	2	1.5%	0%
50+	135	4	2	4.4%	50.0%
Juveniles	619	0	0	0%	0%
6-12	180	0	0	0%	0%
12-17	439	0	0	0%	0%

Table A.8: Naqada periodontal disease.

	Number of observed teeth	Number of teeth with vertical	Number of teeth with horizontal	Percent total teeth affected	Percent affected individuals
Males	1221	4	27	2.5%	25.0%
18-35	160	0	0	0%	16.7%
35-50	960	3	22	2.6%	22.2%
50+	101	1	5	5.9%	50.0%
Females	1059	3	22	2.4%	18.8%
18-35	240	0	7	2.9%	23.1%
35-50	687	0	5	0.7%	6.9%
50+	132	3	10	9.8%	66.7%
Juveniles	235	0	0	0%	0%
6-12	41	0	0	0%	0%
12-17	194	0	0	0%	0%

Hypoplastic Enamel Defects

Table A.9: Hierakonpolis hypoplastic enamel defects.

	Number of observed teeth	Number of chronic lesions	Number of Acute lesions	Percentage of affected individuals	Mean age of occurence
Males	1024	6	105	25.5%	
18-35	776	6	84	33.3%	3.8
35-50	214	0	18	25.0%	3.4
50+	34	0	2	0%	4.0
Females	1390	5	167	13.9%	
18-35	995	2	123	33.3%	3.7
35-50	297	3	38	7.7%	3.5
50+	88	0	6	0%	4.8
Juveniles	554	4	43	40.6%	
6-12	169	2	19	22.2%	3.0
12-17	385	2	24	43.5%	3.8

Table A.10: Naqada hypoplastic enamel defects.

	Number of observed teeth	Number of chronic lesions	Number of Acute lesions	Percentage of affected individuals	Mean age of occurence
Males	328	10	22	25.5%	
18-35	67	0	17	33.3%	3.8
35-50	242	10	5	25.0%	4.3
50+	19	0	0	0%	NA
Females	321	2	4	13.9%	
18-35	73	0	4	33.3%	5.0
35-50	236	2	0	7.7%	5.7
50+	12	0	0	0%	NA
Juveniles	74	0	4	30.0%	
6-12	12	0	0	0%	NA
12-17	62	0	4	30.0%	4.4

Macrowear

Table A.11: Hierakonpolis M1 Macrowear.

	Mandibular M1 mean	Mandibular M1 range	Maxillary M1 mean	Maxillary M1 range
Males	23.4	14.0-36.0	24.7	13.0-39.0
18-35	21.1	14.0-33.0	22.0	13.0-34.0
35-50	27.1	19.0-34.0	28.5	19.0-36.0
50+	32.5	29.0-36.0	37.5	36.0-39.0
Females	20.6	12.0-40.0	21.8	11.0-40.0
18-35	19.8	12.0-37.0	19.8	11.0-40.0
35-50	21.1	15.0-32.0	21.6	15.0-34.0
50+	31.4	24.0-40.0	30.8	21.0-39.0

Table A.12: Naqada M1 Macrowear.

	Mandibular M1 mean	Mandibular M1 range	Maxillary M1 mean	Maxillary M1 range
Males	24.2	16.0-36.0	24.5	15.0-40.0
18-35	18.6	16.0-23.0	18.9	17.0-21.0
35-50	22.8	16.0-360	23.2	15.0-38.0
50+	26.3	17.0-36.0	37.3	32.0-40.0
Females	25.8	16.0-38.0	23.8	16.0-40.0
18-35	24.5	20.0-29.0	28.3	21.0-26.0
35-50	23.0	16.0-36.0	23.7	16.0-39.0
50+	34.8	28.0-38.0	33.1	18.0-40.0

Table A.13: Hierakonpolis M2 Macrowear.

	Mandibular M2 mean	Mandibular M2 range	Maxillary M2 mean	Maxillary M2 range
Males	17.0	6.0-26.0	15.1	5.0-30.0
18-35	14.7	6.0-22.0	12.9	5.0-21.0
35-50	17.8	8.0-25.0	18.3	12.0-30.0
50+	24.5	23.0-26.0	25.0	22.0-28.0
Females	14.5	6.0-34.0	13.6	6.0-36.0
18-35	12.8	6.0-30.0	12.1	6.0-36.0
35-50	15.4	9.0-23.0	14.6	8.0-22.0
50+	25.1	20.0-34.0	18.9	16.0-24.0

Table A.14: Naqada M2 Macrowear.

	Mandibular M2 mean	Mandibular M2 range	Maxillary M2 mean	Maxillary M2 range
Males	17.3	9.0-27.0	16.3	8.0-40.0
18-35	12.5	9.0-18.0	11.3	9.0-14.0
35-50	15.7	10.0-26.0	14.2	8.0-31.0
50+	19.5	10.0-27.0	31.5	19.0-40.0
Females	17.7	9.0-36.0	16.0	8.0-40.0
18-35	21.3	16.0-27.0	9.8	9.0-11.0
35-50	17.1	9.0-36.0	16.1	10.0-38.0
50+	30.0	30.0	26.0	8.0-40.0

Microwear

Table A.15: Hierakonpolis Microwear.

	Number of observed teeth	Mean Feature tally	Mean Pit percentage	Mean Scratch width	Mean Pit width	Percent with polish
Males	41	24.1	0.32	3.52	8.81	68.3%
18-35	29	22.6	0.34	3.41	8.83	65.5%
35-50	9	24.4	0.29	4.30	8.51	77.8%
50+	2	27	0.22	2.11	9.80	50.0%
Females	60	22.5	0.36	3.41	7.70	66.7%
18-35	44	21.7	0.35	3.45	7.62	75.0%
35-50	13	25.6	0.40	3.09	8.33	46.1%
50+	3	20.3	0.39	4.18	6.26	33.3%
Juveniles	22	28.5	0.39	2.89	7.92	100.0%
6-12	8	23.3	0.44	3.08	8.44	100.0%
12-17	14	31.5	0.34	2.79	7.60	100.0%

Table A.16: Naqada Microwear.

	Number of observed teeth	Mean Feature tally	Mean Pit percentage	Mean Scratch width	Mean Pit width	Percent with polish
Males	25	32.3	0.34	2.83	7.33	20.0%
18-35	5	27.2	0.33	3.39	7.34	20.0%
35-50	15	32.9	0.35	2.79	7.34	20.0%
50+	1	19	0.16	2.45	11.46	0%
Females	30	27.7	0.40	3.20	6.63	50.0%
18-35	9	26.3	0.45	3.61	7.87	55.5%
35-50	15	29.7	0.40	3.00	5.79	46.7%
50+	1	26	0.35	4.33	5.84	0%
Juveniles	13	37.9	0.46	3.96	12.44	40.0%
6-12	3	62.3	0.48	2.56	5.56	0%
12-17	10	30.5	0.46	3.08	14.50	60.0%