POPULATION CONTINUITY OR REPLACEMENT AT ANCIENT LACHISH? A DENTAL AFFINITY ANALYSIS IN THE LEVANT

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A

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Abstract

Are material culture changes between late Bronze and early Iron Age inhabitants of Lachish, in modern day Israel, the result of immigrants settling the region, or an in situ evolution of practices by the same indigenous peoples? The research objectives are to: 1) assess dental affinity of an Iron Age Lachish sample relative to its Bronze Age predecessor, and 2) compare data in both groups with European and North African comparative samples to estimate biological affinity within the Mediterranean area. In the process, two competing hypotheses are tested; one postulates continuity and the other population replacement between the Bronze and Iron Age. Using the Arizona State University Dental Anthropology System, dental trait frequencies were compared to determine inter-sample phenetic affinities. The results suggest: 1) biological continuity between the Lachish Bronze and Iron Ages, and 2) a marked level of heterogeneity with closer affinity to some Egyptian and Phoenician groups within the Mediterranean Diaspora. These findings lend support to one of many competing theories identifying the ancient Lachish peoples, while providing an increased understanding of the Bronze and Iron Age transition in the Levant, which is often considered one of the most intriguing and volatile periods in the Near East.

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CHAPTER 1- INTRODUCTION

Research problem and project development

Archaeological investigation of the Bronze and Iron Ages in Ancient Palestine, which includes modern-day Palestine, Israel, and western Jordan (Miller, 1987), has been extensive (Starkey, 1936; Albright, 1937, 1939; Keith, 1940; Tufnell, 1950, 1970; Giles, 1953; Wright, 1955; Barnett, 1958; Ussishkin, 1977, 1980, 1990; Dever, 1990, 1991a, b, 1992, 1993; Wolff, 1991, 1994, 1998; Mazar, 1992, 1997; Finkelstein, 1995a,b, 1999a, b; Mazar et al., 1996; Mazar and Ramsey, 2008; Finkelstein and Piasetsky, 2009, 2010; Finkelstein et al., 2000; Levy, 1995; Joffe, 2002). Changes in settlement patterns, subsistence, trade, and material goods have been analyzed and documented throughout the region. There is, however, much confusion and controversy among archaeologists in discerning ethnicity, cultural change, and the settlements of foreign and indigenous cultures in Palestine.

The transition period between the Late Bronze Age and the Early Iron Age was a time of great change in the Levant (Finkelstein, 1996). New ethnic (distinct biological populations) and cultural groups were immigrating into the region as great foreign militaristic cultures were fighting for political control. Additionally, circumstances brought about by the increasing access to goods and peoples of the Mediterranean greatly influenced indigenous population demography, increased urbanization, and contributed to the instability of the political, cultural, and economic environment (Mazar, 1992; Finkelstein, 1995a,b, 1996, 1999a, 2005; Ussishkin, 2004).

The ancient city of Lachish (also known as the Arabic 'Tell ed-Duweir') is located in the Shephelah region of Ancient Palestine (modern Israel), approximately 32 kilometers south of Jerusalem (Figure 1)(Ussishkin, 1977, p. 735). The site was an important city during most of its long existence, and uniquely reflects the turbulent events unfolding in the greater region of Palestine (Mazar, 1992; Ussishkin, 2004). During the Late Bronze Age Canaanite peoples occupied Lachish as evidenced by architecture, pottery, and other material goods (Tufnell, 1958, 1970; Ussishkin, 2004). A destruction layer marks the end of the period, followed by the settlement of a new cultural group, the Judean Hebrews, who later become known as the Israelites. Archaeologists documented the material culture change between the Bronze and Iron Age levels of Lachish (Starkey, 1936; Tufnell, 1953, 1958, 1977; Ussishkin, 1977, 2004) and have disputed the source of these changes for nearly 80 years. Did the Canaanites abandon the city to the Israelites, or did they assimilate and adopt the cultural values of the new immigrants? There are many potential reasons and opportunities for cultural change during this time; the ancient city likely housed many groups of people considering its close proximity to other ethnic settlements, its long period of occupation, and varied domination throughout the periods by Egyptian, Canaanite, Assyrian, Babylonian, and Israelite peoples (Mazar, 1992).

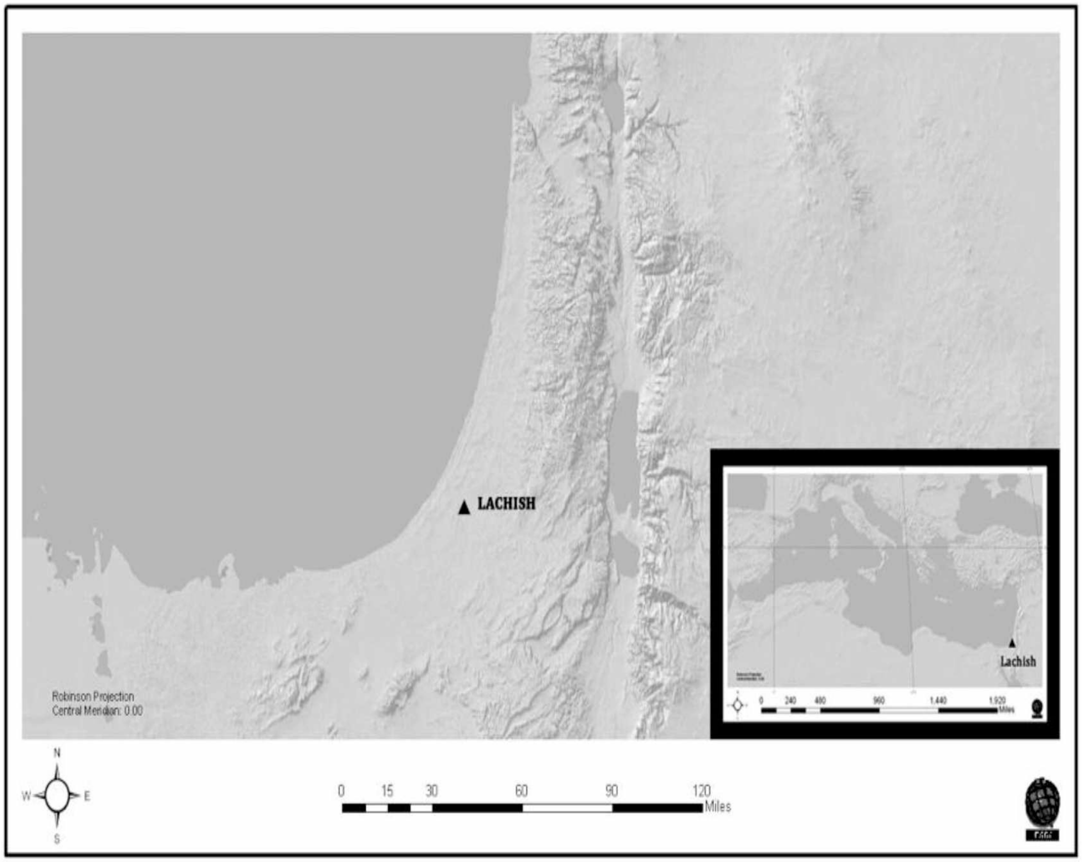


Figure 1. Location of Lachish

In the 1920's and 1930's, British archaeologists (many of whom were Biblical archaeologists) were investigating connections between accounts in the Bible and the region's remnant material culture. In these accounts, Lachish was described as a city won from the Canaanites by the Israelites during the 'Israelite Conquest.' As such, the site became a focal point in the researchers' quest to find Biblical links (Joshua 10:5; Numbers 328, 329, 332; II Kings 14:19; II Chronicles 25:27; Isaiah 36). Two human skeletal collections recovered at Lachish, one dated to the Late Bronze

Age and the other to the Early Iron Age gave researchers the potential to investigate a biological source for cultural change: that is, were signs of cultural change between the Late Bronze and Early Iron Age brought about by immigrants or simply by changing practices of the same indigenous peoples? Various morphometric studies, many with vastly differing conclusions, were performed on the skeletal collections (Risdon, 1939; Berry and Berry, 1972; Finkel, 1976, 1978; Musgrave and Evans, 1981; Keita, 1988). Investigations using dental-based analyses have been minimal (Ullinger et al., 2005). The focus of this thesis is, within a broader bioarchaeological context, to use a comprehensive dental morphological approach to further assess whether diachronic changes evidenced in material culture between the Late Bronze and Early Iron Ages were accompanied by a biological change. In other words, was there population discontinuity at Lachish?

Methodological approach

Bioarchaeology is the study of the biology, culture, and evolution of human populations using skeletal remains, interpreted within an archaeological, historical, and/or contemporary framework (Buikstra, 1977; Stojanowski and Schillaci, 2006). Estimation of biological distances, or the 'affinity' between, among or within populations -- the focus of this thesis -- is one component of bioarchaeological research. Biological distance analyses estimate affinity between human samples and reflect both genetic and environmental differences between populations (Buikstra et al., 1990).

Bioarchaeologists conducting affinity studies examine variation in bone or teeth using metric (e.g., geometric morphometric analysis and craniometrics) and nonmetric measurements (e.g., dental morphology and nonmetric cranial markers) to define patterns that are assumed proxies for genotypic data (Buikstra et al., 1990; Turner et al., 1991; Irish, 1993; Hillson, 1996; Larsen, 1997). Such data are used in conjunction with statistical methods to estimate biological affinity (i.e., model-free), and with models to assess the extent of microevolutionary forces affecting populations (model bound analyses). Affinity studies, in particular, can greatly contribute to our knowledge of activities and interactions of people in the past (Relethford and Blangero, 1990; Turner et al., 1991, Scott and Turner, 1997)

Teeth are excellent subjects for affinity studies not only because of their propensity to survive in the archaeological record, but because of the biological, genetic, pathological, developmental, behavioral, and environmental information they can provide using a range of analytical methods (e.g., morphometrics, isotopic, and genetic) (Turner et al., 1991). Teeth express genetically inherited patterns and features; thus, their evolutionary history facilitates diachronic comparisons among populations (Irish, 2008; Sperber and Hirschfield, 2004). Moreover, morphologically, they are little affected by sexual dimorphism and environmental factors relative to the rest of the skeleton, and are considered by many to be a superior choice for biodistance analyses relative to other elements (Smith and Tchernov, 1992; Turner et al., 1991; Scott and Turner, 1997; Irish, 1998a).

The research presented here utilizes dental nonmetric affinity analysis to address whether material culture changes between the Late Bronze and Early Iron Age inhabitants of Lachish, in Ancient Palestine, are the result of immigrants, or an in situ evolution of practices by indigenous peoples. Data were collected using the Arizona State University Dental Anthropology System (ASUDAS), which is a comprehensive series of plaques for permanent teeth that are used to score non-metric crown and root traits. These traits can be assigned to specific dental complexes in order to determine biological affinity. Cab Smith's mean measure of divergence statistic (MMD), Pearson's R correlation coefficient, and Wright's (1943) isolation-by-distance stepping stone model will be utilized as the main components of the quantitative analyses. Furthermore, heuristic figures including scatterplots and star diagrams are used as qualitative analyses.

Dental morphological variation in archaeological populations is well documented in some parts of the world including Africa and the Americas, and still need to be more extensively documented in other areas including Europe and the Far East. Nonmetric dental analyses have been utilized to assess continuity and/or affinity in many geographic populations: Africa (Irish, 1993, 1997, 1998 a,b,c, 2000, 2005, 2008; Guatelli-Steinberg et al., 2001; Irish and Guatelli-Steinberg, 2003; Irish and Konigsberg, 2007), the Americas (Turner, 1967, 1971, 1983, 1984; Scott, 1973, 1991, 1994; Scott and Dahlberg, 1982; Edgar, 2007), Europe (Scott and Alexandersen, 1992; Cucina et al., 1999; Coppa et al., 2007), and Asia (Turner, 1976, 1983, 1985, 1989; Hawkey, 1998; Higa et al., 2003; Bailey, 2008; Hanihara, 2008; Ricaut et al., 2010).

Objectives and goals of the study

The objective of the present study is to assess continuity or discontinuity as well as general affinity patterns by addressing two research questions, and testing competing hypotheses. Based on prior archaeological investigations, two research questions, of primary and secondary focus, are addressed in this study:

Research Questions.

1. Are material culture changes observed between the Late Bronze and Early Iron Age inhabitants of Lachish the result of immigrants settling the region, or an in situ evolution of practices by the same indigenous peoples?
2. Is the ancient Lachish populace dentally similar to other groups in the greater Mediterranean area, and if so, with whom do they have greater biological affinity?

The primary question investigates biological affinity, while the second question will assess what, if any, other populations contributed to the biological make-up of the Lachish population.

Hypothesis. To answer the primary question, a null and alternative hypothesis formulated from the results of previous archaeological, theological, and biological studies are tested using quantitative analyses including Cab Smith's MMD:

1. *Null hypothesis*- There is no difference between the Iron Age populace of the ancient city of Lachish and their Bronze Age predecessors, therefore representing biological population continuity.
2. *Alternative hypothesis*- There is a difference between the Iron Age populace of the ancient city of Lachish and their Bronze Age predecessors, therefore representing a population replacement or significant positive gene flow.

Additionally, results of this analysis will contribute evidence in the support of one of many competing hypotheses formulated by researchers positing the actual identity of the Lachish sample (Discussed in Chapters 3 and 7).

Significance. This study contributes to the fields of dental anthropology, bioarchaeology, and Syro-Palestinian archaeology in three ways: 1) a more comprehensive inventory of the Lachish skeletal collection at the British Museum of Natural History is provided, 2) a more in-depth analysis of the Lachish collection compared to previous research on the collection is achieved, and 3) an increased understanding of southern Levantine and Lachish prehistory is accomplished.

First, a more comprehensive inventory of the Lachish skeletal collection at the British Museum of Natural History is provided. The Lachish skeletal collection is housed at the British Museum of Natural History, London, England. Over the years, a number of researchers have visited the collection and reported the number of crania present in the collection. Reports have not always been in agreement as to the exact number of crania, or the number of crania with teeth. Among many possible reasons, the disagreement between figures may be attributed to crania on loan at the time of inspection, empty cranium boxes used to keep numerical order in the storage facility, miscounts, and damaged or missing crania over the years. While collecting data for the research here, the following steps were taken to attain an accurate count: each cranium box was removed from the shelf and inspected, empty boxes were not counted; each cranium was inspected for presence or absence of teeth; after a count for each cranium and the absence or presence of teeth was noted, the same counting procedure was repeated a total of three times. The Lachish skeletal collection contains 776 crania: 46 Bronze Age individuals, 32 with teeth and 14 without teeth (may have vestiges thereof); and 730 Iron Age individuals, 340 with teeth and 390 without teeth (may have vestiges thereof). Additionally, a limited number of cranial fragments and various post-cranial elements are included in the collection. For a list of individual crania with and without teeth see Appendix 1.

Second, a more in-depth analysis of the Lachish collection compared to previous research on the collection is achieved. Ullinger et al. (2005) performed dental morphological analysis on the Lachish skeletal collection using ASUDAS. Ullinger et al. (2005) used 17 dental morphological traits and seven comparative samples in the analysis, concluding that the Lachish Iron and Bronze Age samples are biologically continuous. Additionally, Ullinger et al. (2005) supported a level of homogeneity among the pooled Lachish samples. Building on this work, the study presented here includes 26 comparative samples, analysis of 32 dental morphological and osseous traits, and a more in-depth look into possible biological contributors from Mediterranean, Egyptian and Nubian groups.

Lastly, this study contributes to the fields of dental anthropology, bioarchaeology, and Syro-Palestinian archaeology by contributing an increased understanding of southern Levantine and Lachish prehistory, which is accomplished in three ways. First, the dental traits scored between the Bronze and Iron Age inhabitants are compared statistically to estimate if the diachronic groups are biologically continuous or discontinuous. An increased knowledge of the biological identity of the Lachish inhabitants during the period in question is essential to recreate the ethnic/cultural, and religious landscapes in Ancient Palestine – and has the potential to influence the chronological and demographic understanding of the entire region. Researchers have argued for nearly 80 years about the identity of the Lachish skeletal sample; the research presented here addresses crucial evidence in support of one identity hypothesis.

Second, because the dental traits were examined using a standardized system, data in both samples are compared with Southern European and North African samples to estimate biological affinity within the Mediterranean area. The data is then applied to an isolation-by-distance model in order to better understand the pattern of affinity within this area, thus contributing a clearer understanding of the biological landscape in the region. Third, the observations presented here contribute to a worldwide database of dental trait data recorded using the Arizona

State University Dental Anthropology System, thus increasing the known range of global, dental morphological variation.

Organization of the thesis

The goals of this thesis are to: 1) inform the reader, through an archaeological review, of the complex and often conflicting picture of ancient Palestine during the Bronze and Iron Ages, 2) describe the site of Lachish, specifically highlighting the gaps in the archaeological record and identifying how the questions to be investigated contribute to the closing of that gap, 3) provide a methodological background to justify the selection of methods used in this study, and 4) provide results of the research and a discussion of implications and future research. More detail on the chapters that follow is provided below.

Chapter 2 presents specific background information of the Bronze and Iron Ages in Ancient Palestine. This chapter provides Ancient Palestinian archaeological, chronological, and geographical baselines to better contextualize the specific site and cultural information in the next chapter (Ch. 3).

Chapter 3 provides a description of the Bronze and Iron Ages at Lachish. A description of relevant and important archaeological finds, an overview of the possible cultural or biological contributions to the skeletal sample (in the way of immigrant groups who settled in Lachish), a discussion of the legends and controversy surrounding the site, and a literature review of prior affinity studies are included.

Chapter 4 includes a background and literature review concerning dental nonmetric affinity analyses, specifically the Arizona State University Dental Anthropology System (ASUDAS), and the qualitative analyses utilized in the study. Justification for the use of teeth and dental nonmetric analysis is included.

Chapter 5 is the methods and materials section. Here, the background information about samples in the study, details about the methodology, dental traits used, and quantitative analyses are described.

Chapter 6 presents the results of the methods described in Chapter 5. Here, all tables and associated figures of the quantitative analyses are included.

Chapter 7 provides a discussion of the results, an interpretation of the hypothesis. In support of previous work, the results suggest: 1) biological continuity between the Lachish Bronze and Iron Ages, and 2) overall affinity to North African and European populations, with a closer affinity to the Egyptian and Phoenician samples within the Mediterranean comparative samples – based on samples of various age from Giza, Carthage, Greece, Italy, Algeria, and Turkey, among others. These findings expand upon previous work by using a much larger number of traits and comparative samples; they also lend support to one of many competing theories identifying the ancient Lachish peoples, while providing an increased understanding of the Bronze and Iron Age transition in the Levant.

Finally, Chapter 8 presents a summary of the thesis and the conclusions of the study. Suggestions for future research goals and projects are included.

CHAPTER 2- BRONZE AND IRON AGES IN ANCIENT PALESTINE

For over a century, Ancient Palestine has been an obsession for many historians, theologians, and anthropologists. The region has a wealth of archaeological remains spanning many millennia of human occupation. Because Palestine is considered a "crossroads" of the ancient Levant and is the "Holy Land" for Muslims, Jews and Christians, many scholars have devoted their entire careers to research there, which today includes modern Palestine, Israel and western Jordan (Miller, 1987). As the research of Biblical archaeologists primarily concern interpretations of archaeological data within a biblical context, early researchers were predominately seeking to validate events described in the Christian Old Testament, and archaeological interpretations were colored by this agenda. Over time, however, the scope of archaeology in the region expanded, attracting researchers seeking to interpret Palestinian pre-history against the broader context of the ancient Near East (Mazar, 1992). Currently, research concerning ancient Palestine is dominated by three, non-mutually exclusive disciplines: 1) theology/history, 2) biblical archeology, and 3) Near Eastern (Syro-Palestinian) archaeology.

Considering that the purpose of this chapter is to present a regional, cultural history as revealed through archaeology, the information synthesizes work from biblical and Near Eastern archaeologists. While reporting interpretations of archaeological data with a biblical agenda is avoided, summarizing ancient Palestinian events without considering information taken from ancient texts, like the Bible, is impossible. Therefore, the reconstructions and interpretations provided are based on data from the following sources: archaeology, biblical and other ancient texts, Egyptian New Kingdom sources, and ethno historical data.

The chronology of Ancient Palestine is not agreed upon among all scholars. The disagreement concerns the Bronze/Iron Age transition, a period of approximately 400 years in which the subjects of the present research are dated to (Finkelstein and Piasetsky, 2010: 375). The cultural identity of the Lachish individuals may be greater inferred based on which side of the chronological argument one adheres to. As such, a detailed summary of the debated chronology of Palestine is included.

Several basic archaeological paradigms structure the information: environmental determinism, long-term perspective, material cultural (mainly pottery and architecture), and regional aspects (proximity of settlements to each other and to ecological resources) (Finkelstein, 1995b: 349-352). Finally, spatial analysis provides the general framework for presentation of archaeological data. Research will be presented mostly at the *macro level* (Levy, 1995). Macro level studies focus on broad-scale environmental and archaeological distributions of people and objects across landscapes, at and between sites, and within a region. This framework allows dynamics in structure and changes affecting past social organization among and between populations to be analyzed.

Terminology

Early Palestinian periods are based on the worldwide periodization developed by CH. J. Thomsen (1836): the Stone Age, the Bronze Age, and the Iron Age. There have been some modifications to complement Palestinian archaeology: between the Stone Age and Bronze Age, there is an addition of a Copper Age denoted as *Chalcolithic*. Furthermore, the three original periods have been broken down into secondary (e.g. *Middle* Bronze), tertiary (e.g. Middle Bronze *I*), and quaternary (e.g. Middle Bronze I*A*) sub-periods based on pottery assemblages.

Chronology

The chronology of the region is key to understanding who the individuals of the Bronze and Iron Ages at Lachish could be. Lachish was a large, cosmopolitan city, and depending on the period, was occupied by Canaanites, Egyptians, Israelites, Assyrians and Babylonians. So, understanding what period a skeletal collection belongs to, contributes to understanding who they were.

Chronology in ancient Palestine is based on three data sets: relative dating, absolute dating, and Egyptian chronology. Relative dating is largely based on seriation, or the accumulation and interpretation of typological sequences of objects (mainly pottery) among and within sites in the region. Once a relative chronology was established for the entire region, absolute chronological methods were employed and compared. Radiocarbon (C14) dating has been the dominant method for earlier periods (Kirkbride, 1966; Finkelstein and Piasetsky, 2009). The Late

Bronze/Early Iron Age transition is of the most importance to the present study, and is also the period at the heart of an intense chronological debate. Relative upper and lower anchors exist for the greater Bronze and Iron periods. The upper anchor is a correlation between the Egyptian Twentieth Dynasty and material remains (mainly pottery) from several Levantine sites including Level VI of Beth-Shean, Stratum VIIA of Megiddo, and Level VI of Lachish, among others. The lower anchor is correlated with the Assyrian Conquests between 732 and 701 B.C.E. (Mazar, 2005). Here, destruction layers at Dan, Hazor, Lachish, Beth-Shean, Megiddo, and Shea among others have been correlated with Assyrian domination. Between these two generally accepted anchors is the Bronze/Iron Age transition, a period of approximately 300 years in which the subjects of the present research are dated to (Finkelstein and Piasetsky, 2010: 375). As such, pottery phases have been dated in accordance with interpretations of biblical and historical texts in order to create a chronology that is applicable to Palestine and the entire eastern Mediterranean region.

Background: Pottery and chronology. The Philistines and the Israelites of Ancient Palestine have been archaeologically identified and spatially defined primarily using pottery (Bunimovitz and Yasur-Landau, 1996). This pottery, specifically that of the Philistines, has been used to construct the chronology of the entire eastern Mediterranean Region at the end of the second millennium B.C.E (Finkelstein, 1995a). The chronology is anchored to the settlement of the Philistines in the southern coastal region of Canaan, as seen in the archaeological record. The Philistine settlement event is linked to the Egyptian Medinet Habu inscriptions and reliefs of the Late Bronze/Early Iron Age transition. The ancient inscriptions describe the wars between Ramses III and the Sea Peoples, including the Philistines, and represent one of the only events of the Bronze and Iron Ages in Palestine that can be seen both in ancient texts and the archaeological record. Thus, a connection between the chronology of Egypt and archaeology of the Levant, Cyprus, and Anatolia was established (Finkelstein, 1995a).

Philistine pottery. Mycenaean pottery is a type that was produced in Bronze Age Greece (Furumark, 1941a). After widespread destruction in Greece at the end of the 13th century B.C.E, new types of Mycenaean pottery are seen in the archaeological record; among these is the Mycenaean IIIC1b, which was most common among Greek refugees in Cyprus (Furumark, 1941 a, b). Pottery identical to Mycenaean IIIC1b ware was uncovered in Canaan in strata representing the earliest settlement levels of the Sea Peoples (Finkelstein, 1995a). Thus, the Mycenaean IIIC1b pottery in Canaan came to be associated with a group of Mycenaean Greeks, the Philistines, who probably immigrated toward Palestine and encountered Ramses III and his armies (Albright, 1975). Generally, this Philistine/Mycenaean IIIC1b pottery is referred to in the literature as, simply, Monochrome pottery (Mazar, 1992).

The term "Philistine Pottery" is reserved for ware that is considered to have developed from the Monochrome type after a period of settlement and acculturation (Mazar, 1992). Biochrome pottery is also an Aegean-like ceramic attributed to the Philistines, which is believed to have developed from the original Monochrome ware by combining Philistine, Canaanite, and Egyptian traditions. (Mazar, 1992; Dothan, 1982, 1985).

Using pottery in the archaeological record as an ethnic marker can be a complex and problematic task. Defining ethnicity among modern groups is difficult as ethnic boundaries are flexible and constantly changing; such a challenge is magnified when discerning ethnicity from material remains alone (Barth, 1969). Many studies have demonstrated that ethnic identities and pottery types do not have a one-to-one correlation, and that if possible one should avoid using pottery alone (Kramer, 1977; Bunimovitz, 1990; Muhly, 1992). While pottery is still the dominant ethnic identifier for Near Eastern archaeologists, other categories of evidence used by archaeologists in Palestine are settlement patterns, demography, and subsistence patterns (Dever, 1995a, b, c). As Dever (1993: 30) stated, "… in archaeology pottery still remains our most sensitive medium for discerning cultural contact and cultural change."

The chronological debate. The central chronological debate concerns the dates of two important events and is limited to the Late Bronze and Early Iron transition. The first event of concern is the date of Philistine settlement in Canaan and the second is the end date of Egyptian rule in Canaan. There are two schools of thought, one advocating for and the other against the wholesale lowering of the traditionally held dates of these events by approximately 80 years. The implication is that, due to recent archaeological finds and analyses, stratigraphy conventionally associated with the United Monarchy of David and Solomon (as described in the Bible) "have become" too young. Thus an archaeological controversy arose, in which chronology is key (Finkelstein, 1995a, 1996; Mazar, 1997; Bruins et al., 2003).

W.F. Albright (1975) developed the 'Philistine Settlement Paradigm', in which he proposes that during the early Egyptian 20th Dynasty, Egypt held territories in southern Canaan. Ramses III in his eighth year of reign (1175 B.C.E) (Wente and Van Siclen, 1976: 218) defeated the Sea Peoples (among them Philistines) and deposited them as vassals in the Egyptian controlled colonies. The Philistines, after a short time, rejected Egyptian authority and claimed the colonies as their own. This paradigm was based on a variety of archaeological and (predominately) textual evidence, which has been widely accepted to this day (Weinstein, 1992; Bietak, 1993; Stager 1995, Finkelstein, 1995a).

The Modified Conventional Chronology. Based on the Philistine Settlement paradigm, a number of theories concerning the date of Philistine settlement and the end Egyptian rule have been proposed, the dominant being the *Modified Conventional Chronology (*formally *High Chronology),* which is supported by a number of scholars (Mazar, 1992, 1997, 2005; Ben-Tor and Ben-Ami, 1998; Ben-Tor, 2000; Bunimovitz and Faust, 2001; Dever, 2001; Byrne, 2002; Harrison, 2003; Ben-Shlomo et al., 2004; Kletter, 2004)*.* Supporters of the *Modified Conventional Chronology* argue that monochrome pottery represents the initial settlement of the Philistines in Canaan between 1175 (the eighth reigning year of Ramses III) and 1150 B.C.E. Furthermore, the Biochrome pottery, after a level of acculturation between the Philistines and surrounding groups, is dated to the mid-12th century

B.C.E. (T. Dothan, 1982, 1985, 1992; Mazar, 1985, 1992; Singer, 1985; Oren, 1985; Stager, 1985, 1991). This argument is based on analyses of several sites, including Mazar's (1985) assessment of the artifacts from Megiddo where the Philistine Biochrome pottery sherds post-date Stratum VIIA (time of Ramses III- Ramses VI), and Tell el-Far'ah, which yielded scarabs of Ramses III and Ramses IV (Mazar, 1985; Finkelstein, 1995a). Proponents of the *Modified Conventional Chronology* argue against the lowering of the traditionally accepted dates of Philistine settlement and Egyptian exodus.

The Low Chronology. There have been, however, scholars who have rejected part or all of the 'Philistine Settlement Paradigm' using primarily archeological evidence to argue a *Low Chronology*, in which the traditional dates of Philistine settlement and Egyptian exodus are lowered by 80 years. The first archaeologist to propose the modified chronology was Ussishkin (1985) later to be supported by many others (Finkelstein, 1995a,b, 1996, 1998, 1999a,b, 2005; Finkelstein and Piasetsky, 2006, 2007, 2009, 2010; Gilboa and Sharon, 2001, 2003; Herzog, 2002; Knauf, 2002; Gilboa et al., 2004; Fantalkin et al., 2011). Supporters of the *Low Chronology* agree with advocates of the *Modified Conventional Chronology* that the locally made Monochrome Ware represents the initial settlement of the Philistines in Canaan. The disagreement, as stated by Finkelstein (1996:180) is as follows:

> However, Monochrome pottery has not been found in any of the Twentieth Dynasty Egyptian strongholds in the south. Especially crucial are Stratum VI

> at Lachish and Stratum IX at Tel Sera, which were occupied at least until the later days of Ramses III. In fact, there is good reason to suggest that the Egyptian domination in southern Canaan lasted until the days of Ramses VI, that is, up to *c.* 1135 B.C.E.

Finkelstein rejects the notion that daily-use pottery would remain restricted to the original Philistine centers for decades without finding its way to nearby sites 5-7 kilometers away. He argues that Monochrome pottery must have postdated Egyptian domination in Canaan, appearing only in 1135 B.C.E. or even later, therefore pushing the appearance and use of the Philistine Biochrome pottery to the early-mid 10th century B.C.E (Finkelstein 1995, 1996: 179-80, 1998; Ussishkin 1985, 1993).

Ultimately, the *Modified Conventional Chronology* places the appearance of an increase in fortifications, monumental building activity, evidence of advanced administration, mass production of a new red slip and hand burnished pottery (as opposed to the painted pottery of the Philistines and the Canaanites), settlement in the highlands, and evidence of writing in Palestine during the period of the United Monarchy of Solomon and David. This time period is characterized by the emergence of Israel from Palestine[1] during the first half of the 10th century B.C.E., thus associating the increase in state-like functions with the unification of the

[1] As is written in the Bible, though there is limited archaeological evidence for the United Monarchy. For more details see Finkelstein, 1995b, 1996, 1999a, b; Dever 1995 a,b,c; 1997, among many more.

monarchies in Israel. The *Low Chronology* places the increase of the previously mentioned events in the early ninth century, after the proposed time of the United Monarchy, which in turn suggests that the previously held connection between the archaeology of Lachish and the events of the Bible, is lost (Finkelstein, 1996: 185; Mazar, 2005: 21).

Continued excavations in the region, renewed analyses of past excavations, and radiocarbon dating from parties on both sides of the debate have not resolved the issue. While both the *Modified Conventional Chronology* and the *Low Chronology* use radiocarbon dating, the limitations of this method when attempting to resolve a time-span of merely 80 years lead to a wide variety of possible calibrated dates and interpretations (for a detailed account see Finkelstein 1995a, 1996, 1998, 2005; Finkelstein and Silberman, 2006; Finkelstein and Piasetsky, 2007, 2009, 2010; Kletter 2004; Mazar 2005 among many others).

Below is a chronology table (Table 1) listing the *Low- and Modified Conventional Chronologies* from ancient Palestine as presented by Mazar (1992), Finkelstein and Piasetsky (2010), and the corresponding Egyptian chronology (for reference) as presented by Kitchen (1991). The *Modified Conventional Chronology* periods and dates in the table were acquired using a variety of relative and absolute dating techniques taken from a number of different studies in order to create a chronological "skeleton" for Palestine (Mazar, 1992: 30). The transition period dates of the *Low Chronology* listed in the table are figures produced from a Bayesian model of radiocarbon dates from 142 short-lived samples of grape seeds, olive pits and buried pottery sherds from 38 strata at 18 sites. The ceramic phases are well-defined ceramic phases for the region, which are used as sequential horizons (Finkelstein and Piasetsky, 2010: 375). The transition periods do not align exactly between the ceramic phases because Finkelstein and Piasetsky chose the "simplest possible model of abutting the sequential phases" with no overlap and no significant gaps (Finkelstein and Piasetsky, 2010: 375). Additionally, Finkelstein and Piasetzky's (2010) chronology only concerns the Bronze/Iron transition and subsequent Iron Age phases.

Table 1. Chronology of Palestine
(Kitchen, 1991; Mazar, 1992; 2005; Finkelstein and Piasetsky, 2010)

<table>
<tr><th>Modified Conventional Chronology Archaeological Periods of Palestine</th><th>Modified Conventional Chronology Date (B.C.E)</th><th>Corresponding Dynasties of Egypt</th><th>Low Chrono-logy Ceramic phases of Palestine</th><th>Low Chrono-logy Date of phase (B.C.E)</th><th>Low Chronology Transition between phases (B.C.E)</th></tr>
<tr><td>Pre-Pottery Neolithic A</td><td>ca. 8500-7500</td><td>Paleolithic/Mesolithic?</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Pre-Pottery Neolithic B</td><td>7500-6000</td><td>Fayum Neolithic</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Pottery Neolithic A</td><td>6000-5000</td><td>Fayum Neolithic</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Pottery Neolithic B</td><td>5000-4300</td><td>Taso-Badarian</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Chalcolithic</td><td>4300-3300</td><td>Naqada I-II</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Early Bronze I (EBI)</td><td>3300-3050</td><td>Naqada II</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Early Bronze II-III (EBII-III)</td><td>3050-2300</td><td>Naqada II, 1st-6th Dynasties</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Early Bronze IV/Middle Bronze (EBIV-MB I)</td><td>2300-2000</td><td>6th-11th Dynasties</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Middle Bronze IIA (MB IIA)</td><td>2000-1800/1750</td><td>11th-12th Dynasties</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Middle Bronze IIB-C (MB IIB-C)</td><td>1800/1750-1550</td><td>12th-17th Dynasties</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Late Bronze I (LBI)</td><td>1550-1400</td><td>18th Dynasty</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Late Bronze IIA-B (LBII A-B)</td><td>1400-1200</td><td>18th-19th Dynasties</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Iron IA (I-IA)</td><td>1200-1140/30</td><td>19th-20th Dynasties</td><td>Late Bronze III</td><td>-1098</td><td rowspan="11">1125-1071
1082-1037
1045-1021
960-899
902-866
785-748</td></tr>
<tr><td rowspan="2">Iron IB (I-IB)</td><td rowspan="2">1150/40-980</td><td rowspan="2">20th-21st Dynasties</td><td>Early Iron I</td><td>1109-1047</td></tr>
<tr><td>Middle Iron I</td><td>1055-1028</td></tr>
<tr><td rowspan="4">Iron IIa (I-IIa)</td><td rowspan="4">980-840/30</td><td rowspan="4">21st-22nd Dynasties</td><td>Late Iron I</td><td>1037-913</td></tr>
<tr><td>Early Iron IIA</td><td>920-883</td></tr>
<tr><td>Late Iron IIA</td><td>886-760</td></tr>
<tr><td>Transitional Iron IIA/B</td><td>757 -</td></tr>
<tr><td>Iron IIb (I-IIb)</td><td>840/30-732/01</td><td>22nd-25th Dynasties</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Iron IIIa</td><td>732/01-605/586</td><td>25th-26th Dynasties</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Iron IIIc</td><td>605/586-520</td><td>26th Dynasty</td><td>n/a</td><td>n/a</td></tr>
</table>

Geographic Setting of Palestinian Settlements

Before describing the Bronze and Iron ages in Palestine, describing the geographic setting is important as the environment directly impacts the development of settlement and economic systems (Finkelstein, 1995b). The geographic location of ancient Palestine has greatly determined its role in the history of the Middle East (Mazar, 1992). Ancient Palestine was centered between the two ends of the Fertile Crescent, between Egypt in the south and Syria and Mesopotamia in the north, making Palestine the "bridge" between any conflict, alliances, or trade agreements among their prosperous neighbors. The Sinai Desert formed a natural barrier between Egypt and Palestine where an international highway known as the "Via Maris" (Way of the Sea) was the only road between Egypt and Asia. A second highway running through ancient Palestine called "King's Highway" connected Syria with the Red Sea and Arabia (Orni and Efrat, 1966). Ancient Palestine is between the Mediterranean Sea to the West and a large desert to the east.

The human response to this environment resulted in a plethora of cultural and subsistence adaptations. While much of the region is dominated by a Mediterranean (maritime) climate, the southern part of the territory is generally very arid and evidence for habitation appears only in selected periods. The region can be separated into several longitudinal strips with varying topography, breadth and altitude: the coastal plain, the Shephelah foothills, the central mountain ridges, the Judean Desert, the Rift Valley, the highlands and lowlands of the Rift Valley, and the eastern desert. Valleys running east-west throughout the country transect these regions, allowing for natural communication pathways to be established by inhabitants between the coastal plain and the inner parts of the territory (See Figure 2). Thus, Palestine, like the rest of the Levant, is a biologically and culturally heterogeneous region that was influenced by the ever-shifting axes of power throughout the history of the Near East- Egypt and Mesopotamia (Orni and Efrat, 1966).

The Bronze Age in Palestine

Settlement patterns, population demography, and subsistence methods differed significantly between the Bronze Age and previous periods in Palestine. The period is characterized by “cyclic oscillations” of urban development and subsequent collapses, and ever-changing conditions under Egyptian sovereignty (Finkelstein, 1995b: 349). Scholars of the region have attributed the urban rises and collapses in the Palestinian Bronze Age to a number of events including conquests by invading peoples, Egyptian military campaigns, and the gradual socio-economic evolution of the local populace (Dever, 1995b,c; Mazar, 1992; Finkelstein, 1995b, 1996; Golden, 2004). Unless otherwise noted, the following description is limited to a review of the Bronze Age and secondary sub-periods: Early Bronze Age (EB), Middle Bronze Age (MB), and Late Bronze Age (LB).

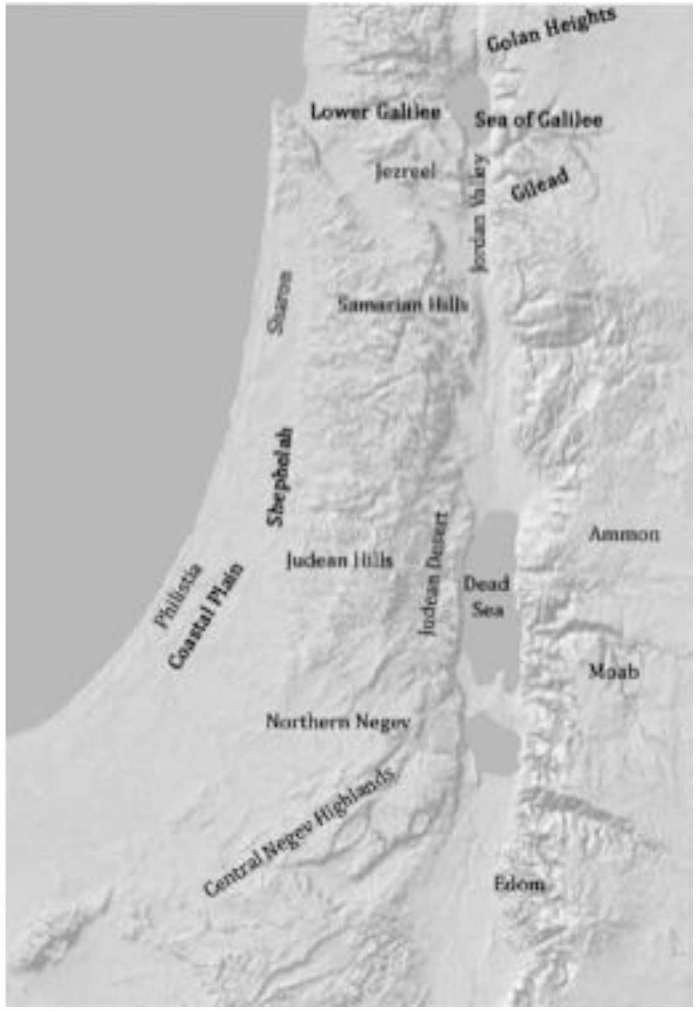


Figure 2. Map of geographic regions in Ancient Palestine.

Settlement and burial patterns. Most Palestinians in the Early Bronze Age (EB) (ca. 3300-2300 B.C.E.) were living in modest, unfortified, agricultural settlements ranging from 3-10 acres and situated near roads and water sources. Many earlier Chalcolithic sites were abandoned, yet population continuity is observable; at least 30% of EB sites were used continuously between periods (Mazar, 1992: 94). Many new settlements were established in the EB in the fertile regions of Palestine including the Shephelah, the Jordan Valley and the central hill country. The beginnings of intensive urbanization throughout the Levant during the EB are evidenced by an increase in fortified buildings, temples, palaces, granaries and water reservoirs. Many of these settlements became important, large urban centers in the Middle Bronze Age (MB) and Late Bronze Age (LB): Megiddo, Beth-Shean, and Tel Halif among many others (Mazar, 1992). During the transition from the EB to MB (ca. 2300/2250-2000 B.C.E) urbanization decreased as evidenced by abandoned settlements and an increase in semi-nomadism and pastoralism. One of the largest, excavated sites belonging to this period is Beer Resisim, which is estimated to have had approximately 75 individuals with a few single chambered, rounded dwellings and several livestock pens (Kenyon, 1966; Dever, 1987).

Urbanization increased immensely in the MB (ca. 2000-1550 B.C.E), especially in the coastal plain, which is characterized by the development of the Canaanite culture and increasing relations with Egypt. Here, a ‘cultural revolution’ in settlement patterns, urbanism, architecture, pottery, metallurgy, and burial customs is seen in the archaeological record. New fortified settlements with massive earth ramparts, towers, walls, and palaces are found all over Palestine at sites like Tel Burgah, Tel Mevorakh, Tel Zeror and Tel Ifshar (Dothan, 1976; Kempinski and Niemeier, 1990; Mazar, 1992).

By the LB (ca. 1550-1200/1098 B.C.E), Palestine was under Egyptian sovereignty and experienced another decrease in population density and urban settlement. In fact, Mazar (1992: 243) describes the “most amazing” feature of the LB as the almost total absence of any fortifications at excavated sites, excluding the defenses continued from the MB. Mazar attributes the lack of defense in Canaanite cities to the absolutism of Egyptian rule (Mazar, 1992).

During the EB/MB transition, burial customs can be generally grouped into three, region specific styles: shaft tombs in western Palestine sites; megalithic dolmens under tumuli in the Golan Heights and Upper Galilee; and tumuli found in Negev, all of which possessed one or a few individuals (Lapp, 1966; Epstein, 1985; Mazar, 1992). The change in burial pattern seems to accompany a change in social structure and settlement patterns. Multiple burials are often used to accommodate multi-generational families in an urban setting, while single and secondary burials seem to compliment a seminomadic lifestyle (Kenyon, 1960; Ben-Tor, 1992; Mazar, 1992; Levy, 1995).

Multiple burial caves came back into use during the urbanization periods of the MB and LB. Additionally, the construction of tombs under houses can be seen in this period, especially in Megiddo where many of these types of tombs were uncovered. A common internment style specific to the MB is the burial of infants in jars under rooms and courtyards of the house (Kenyon, 1957, 1969; Matthiae, 1980). Grave goods for all sub-periods varied between sites and regions, but generally consisted of various forms and types of pottery, metal objects, ointment juglets, and jewelry (Tufnell, 1958; Mazar, 1992).

Subsistence Patterns. The distribution of sites and the assemblages of faunal bones recovered from sites suggest that sheep and goat herding formed the traditional base of the economy in the EB, but by the LB cereal and legume agriculture dominated. Large faunal assemblages, mostly long bones from sites like Hazor, Aphek and Tel Dalit, indicate that domesticated goat and sheep meat, specifically cuts from limbs, was an important part of the diet in all of the Bronze Age (Golden, 2004).

During the EB, there is evidence that horticulture was first introduced. Flax, cereals (specifically barley and wheat) and legumes were excavated in abundance in Arad. Major crops of grapes and olives are found at sites in the hill country. Remains of grape, pomegranates, dates, olives, and figs at various sites in the region suggest advanced horticulture (Mazar, 1992). Products of these crops were being traded with other villages and cities as well as being exported to Egypt. In Hazor, a canal system dated to the MB was excavated. The canals had stone roofs and ran for hundreds of meters (Golden, 2004). This development is associated with the rise of a strong urban culture and specialization in Palestine by EBII-III (Ortner, 1979; Dothan, 1985; Mazar, 1992; Finkelstein, 1995b, 1999).

The collapse of the LB culture is likely connected to the broader events taking place in the Eastern Mediterranean, Egyptian instability during the 13th and 12th centuries B.C.E, and local economic and socio-cultural developments (Finkelstein, 1995a,b, 1999a).

The Iron Age in Palestine

The decline of the LB Canaanite culture was a gradual process in parts of Palestine. Canaanite culture continued to thrive in cities like Megiddo, where after the LB destruction layer, the city was rebuilt in the Canaanite fashion with Canaanite ware being manufactured and used. Continuity in pottery types, construction, and cult items are seen in many Early Iron Age sites, however, significant differences have been observed (Golden, 2004). The Iron Age is characterized by a wave of increased settlement and population growth, in part due to the alternating practice of nomadism and sedentarism of local indigenous groups in response to changing political, economic, and social events in the entire region (Finkelstein, 1995b: 362).

The Iron Age in Palestine also saw the end of Egyptian presence in the region, the emergence of the Israelites, and the settlement and eventual decline of the Sea Peoples, Philistines, and Phoenicians (Herr, 1988; Joffe, 2002). The wave of settlement eventually led to the development of Hebrew territorial nation-states Judah (south) and Israel (north) and their successive and short-lived United Monarchy. The development into a nation state is evident in the archaeological record in many sites across the entire region by a sharp increase of administrative centers, public buildings, water supply projects, industrial centers, and written administrative documents (Joffe, 2002). The developments of the Iron Age compared to the Bronze Age can best be described according to the dominant cultural groups of the period, which include the Canaanites, Philistines, and the Israelites (Mazar, 1992; Golden, 2004).

The Canaanites

The Canaanite culture continued to exist in limited areas of the coastal plain and the northern valleys of Palestine (Mazar, 1992; Golden, 2004; Ussishkin, 2004). Some Canaanite sites were undoubtedly under Philistine control, yet Canaanite pottery, residences, and cult objects continued to be manufactured. Megiddo and Beth-Shean were both destroyed after the end of Egyptian rule, and then rebuilt in a combination of Canaanite and Philistine traditions (Mazar, 1981).

During the 11th century B.C.E. the Phoenician culture began to develop. The 'Phoenician Culture' is a term founded from the Greek word for the descendants of Canaanites. The culture is founded on specific aspects of the Canaanite culture in the cities of Tyre and Sidon who eventually came to build colonies in the Western Mediterranean region (Pritchard, 1968). At the genesis of this culture, the Phoenicians were primarily defined by their 'Phoenician Biochrome Ware', which was a blend of Canaanite, Philistine, and the new Phoenician technologies (Mazar, 1992).

The Philistines

In the Early Iron Age in Palestine, a series of migrations and settlements were occurring in the region. Many of these migrations were likely the outcome of the turmoil in the Aegean and Anatolian regions of the Mediterranean (Mazar, 1992; Finkelstein, 1995a; Golden, 2004). The Philistines are only one faction of the migrants referred to by regional scholars as the 'Sea Peoples' (Wachsman, 1981; Dothan, 1982; Brug, 1985; Mazar, 1992; Finkelstein, 1995a; Golden, 2004). After a series of battles and destruction in Greece, somewhere near the end of the 13th century B.C.E., new forms of Mycenaean pottery attributed to the Philistine culture appeared in Canaan. This appearance was accompanied by settlements in new and pre-existing sites with cultural attributes significantly differing from the local Canaanite and Egyptian populations (Mazar, 1992).

Five main cities are attributed to the Philistine culture in the Iron Age: Gaza and Ashkelon of the Coastal Plain, Ashod in the interior, and Gath and Ekron in the Shephelah (Mazar, 1992; Golden, 2004). Ashod, under Philistine control, was a large, densely populated, fortified city as is evidenced by large residential areas and extensive city walls (Dothan and Porath, 1982). The evidence for Philistine settlement in the Shephelah is inconclusive. Many sites in the region contain Philistine artifacts; however, Lachish, the largest and most important city in the region, contained no appreciable Philistine artifacts, which brings the date of Philistine settlement in the Shephelah into question (Ussishkin, 1985, 2004; Mazar, 1992; Finkelstein, 1995a). Evidence for sustained occupation of the northwestern Negev and southern Coastal Plain is substantial at sites like Tel Sera, Tell Jemmeh, Tell el-Far'ah and Deir el-Balah (Mazar, 1992).

The first wave of Philistine settlement is characterized by the appearance of Philistine Monochrome pottery in the archaeological record in Canaan (Mazar, 1992; Finkelstein, 1995a). Currently, archaeologists do not know if there were subsequent waves of migrations, or if the bulk of the Iron Age Philistine populace arrived in one migration event (Finkelstein, 1995a). Biochrome Ware is only one example of how the Philistines maintained their own Aegean/Anatolian customs while integrating local indigenous culture. This bilateral relationship between the two cultures and Philistine political and cultural history indicate that the Philistine culture in Palestine did not come to an end, but assimilated with the indigenous peoples (Mazar, 1992).

The Israelites

Fierce debate surrounds the questions of 'who, what, when, where and how' the Israelites emerged as a distinct ethnic group. Generally, four competing hypotheses provide explanation of this cultural emergence.

First, the *military conquest (*or the *Israelite Conquest)* hypothesis postulates that a group of Hebrews came from outside the region, annihilated and then settled the defeated Late Bronze Canaanite towns and cities (Albright, 1939; Wright, 1962; Lapp, 1967; Yadin, 1979). The majority of evidence supporting this hypothesis comes from biblical sources, although archaeological evidence of destruction layers accompanied by culture change exists in at least two sites: Lachish and Bethel (Kelso, 1968; Finkelstein, 1995a).

Second, the *long-term perspective* hypothesis postulates that the Israelite settlement was the outcome of three waves of settlement oscillations in the region due to changes in the reliance of those people on combinations of pastoralism and agriculture with varying degrees of sedentarism (Finkelstein, 1995b, 1996). This hypothesis is based on archaeological excavations and surveys revealing similarities in settlement, demographic, and cultural patterns between the peoples of the settlement waves.

Third, the *peaceful infiltration* hypothesis postulates that the Israelite settlement was a gradual infiltration of peoples from the hill country into the lowlands after years of conflict with neighboring Canaanite settlements (Alt, 1939; Aharoni, 1957; Weippert, 1971).

Fourth, the *social revolution* hypothesis postulates that a classes' conflict paved the way to a more equal and peaceful civilization (Mendehall, 1962; Gottwald, 1979; Ahlstrom, 1986). The two former hypotheses have little to no archaeological evidence, either in the hill country, or in other parts of the Israelite territories (Finkelstein, 1995b).

Finkelstein (1996:209) views the rise of early Israel as one phase of many in the long-term, cyclic processes of settlement oscillations associated with the rise and fall of territorial entities in the highlands of Palestine. Three settlement oscillations of importance here are the rise and collapse of civilizations in the central hill country; the first two occurred during the Middle and Late Bronze Ages and degenerated completely, while the third led to mature statehood in the Iron Age (Finkelstein, 1996: 207, 1995).

Archaeological excavation and survey revealed new settlement patterns and hundreds of new sites that formed in the Iron Age. Many of these settlements, which began as small villages, condensed and grew to become large cities like Megiddo, Hazor, Dan, Lachish and Gezer (Mazar, 1992; Finkelstein, 1996; Golden, 2004). In Iron I, settlements were inhabited in Lower and Upper Galilee, Samaria and Ephraim, Benjamin, and parts of Cis- and Transjordan (Aharoni, 1957, 1978; Weippert, 1971; Finkelstein and Vronwy, 1986; Mazar, 1992). These sites are associated with the emergence and dispersion of politically unified Israelite tribes based on pottery and architecture; although, they cannot be indisputably identified as such (Mazar, 1992). By the Iron II, the population of the hill country expanded west, and many sites in the region doubled in size (Golden, 2004). The beginning of the ninth century B.C.E appears to be the period in which the United Monarchy arose (Golden, 2004). The short-lived political unification of Judah and Israel is characterized by a sharp increase of standardized administrative centers, public buildings, water supply projects, industrial centers, and written administrative documents in numerous sites across the north and south (Joffe, 2002). Political unification is further evidenced by ceramic ware used for serving food in this period, which was treated with a red slip burnish, while cooking ware was not (Faust, 2002). This change in the treatment of specific types of ware represents a new method not seen until the Iron II and reveals a trend towards uniform production and a decrease in regional variation (Aharoni, 1982; Dever, 1995a,b,c).

The main components of the typical Iron Age towns are the fortification system, a city gate, a piazza, street networks, public structures, drainage and water supply systems, dwellings, and industrial installations (Mazar, 1992). Settlements of this period can be divided into capital cities, district administration centers, and country towns (Herzog, 1978). The capitals of Judah and Israel (Jerusalem and Samaria) were large cities of approximately several dozen acres (Finkelstein, 1999 a,b).

In smaller Iron Age administrative centers like Lachish, Hazor, and Megiddo, city planning is archaeologically documented and understood. At Gibeon two water projects were constructed, one replacing the other, and consisted of underground shafts and tunnels leading to a fresh spring (Wolff, 1991, 1994, 1998; Joffe, 2000). The mass production of oil, wine, textiles and specialized products like perfume and leather goods can be seen in the archaeological record, especially in places like Ekron who probably supplied Jerusalem with the majority of their oil and wine products (Wolff, 1991, 1994, 1998).

The Iron Age in Palestine, for the most part, was a golden age for the region. After approximately 75 years of political unification, due to tensions between the southern and northern peoples, the United Monarchy separated back into two distinct factions: The Judean Kingdom in the south, and the Kingdom of Israel in the North (Mazar, 1992; Golden, 2004) The end of the Iron Age however, saw the collapse of both nation-states with the successive dominations by Assyria and then Babylon in the following periods.

CHAPTER 3- LACHISH

Archaeological background

The changing and often volatile events of the Bronze and Iron Age in ancient Palestine are reflected at the site of Lachish. The shifting axes of power, changing demographic patterns, and fluctuating economic stability occurred acutely and repeatedly at Lachish. Because the objective of this study is to investigate biological continuity and affinity between and among the peoples at Lachish and the greater Mediterranean region, it is important to understand the known biological and cultural changes that occurred at the site.

The tell was settled in the Neolithic and Chalcolithic Periods, re-occupied in the Early/Middle Bronze transition, abandoned and re-fortified in the Middle Bronze and again in the Iron Age (Tufnell, 1977; Gophna and Blockman, 2004; King, 2005). Several different cultural groups controlled the ancient city during its existence, which has resulted in an unclear picture of its archaeological record.

Members of the Wellcome-Marston Expedition under the patronage of Sir Henry Wellcome, Sir Charles Marston and Sir Robert Mond excavated the site of Lachish from 1932-1938. Mr. John Starkey led excavations from 1933-1938 until he was murdered by bandits near Hebron while on his way to the opening ceremonies of the Palestine Archaeological Museum in Jerusalem (Tufnell et al., 1940). Mr. Starkey, Harry Torczyner, Alkin Lewis and Lankester Harding wrote the first of a six volume series of accounts meant to cover all aspects of the excavations; it was published after Mr. Starkey's death in 1938. Olga Tufnell, an archaeologist at the site from 1932-1938, was involved in the research and editing of the second volume, and after World War II became lead author of the series, which resulted in publication of volumes III and IV. Much later, during the summers of 1966 and 1968, Y. Aharoni led an excavation at Lachish, followed in 1973-1987 by David Ussishkin. Eventually the site of Lachish was declared a National Park and may, in the future, be open to the public.

Stratigraphy

Members of the Wellcome-Marston Expedition determined strata at Lachish by cutting a cross-section at the northeast corner where at least four occupational levels were observed before the destruction of the last Bronze Age city (Level VI) (Tufnell, 1953). Starkey used the term 'level' to designate a stratum. Through continued excavations, Levels I-VIII were firmly established and named by counting strata from the surface downward. For continuity, Ussishkin adopted the same terms but independently determined the stratigraphy (Table 2) (Ussishkin, 2004).

Table 2. Chronology at Lachish and corresponding periods of Palestine (Ussishkin, 2004).

Period	Ussishkin's Levels	Starkey's Levels	Observations	Sample
Pottery-Neolithic			Small settlement on mound	
Chalcolithic			Small Ghassulian settlement on mound	
Early Bronze IA			North-West Settlement	
Early Bronze IB			Small settlement on mound	
Early Bronze II			Small settlement on mound	
Early Bronze III			Extensive settlement on mound	
ca. 2200 B.C.E. Destruction or desertion of settlement				
Intermediate-Bronze Middle Bronze I				
Late Middle Bronze I				
Middle Bronze II		VIII	Fortified City	
ca. 1550 B.C.E. Destruction by fire				
Middle Bronze II				
Late Bronze IA				Lachish Bronze Age Sample
Late Bronze IB				
Late Bronze II				
Late Bronze IIIA	VII	VII	Fosse Temple III	
ca. 1200 B.C.E. Destruction by fire				
Late Bronze IIIB	VI	VI	Prosperous Canaanite city; Egyptian hegemony	
ca. 1130 B.C.E. Destruction by fire, occupation gap during Iron I				
Iron IIA	V	V	Judean kingdom period; unfortified settlement	Lachish Iron Age Sample
	IV	IV	Central Judean fortified city	
Iron IIB	III	III	Rebuilt central Judean fortified city	
701 B.C.E. Destruction by Sennacherib, occupation gap				
Iron IIC	II	II	Judean fortified settlement; 'Lachish Letters'	
588/6 B.C.E. Destruction by Nebuchadnezzar, occupation gap				

Archaeology: Early Bronze (EB- ca. 3300-2300 B.C.E)

Modified cave dwellings originally attributed to Chalcolithic peoples by Tufnell (1958) were later dated to the EBI; associated structures included doorsills, sunken hearths, and lined storage pits (Albright, 1937; Tufnell, 1977; Ussishkin, 2004). Worked and worn stones were discovered on the surface and in caves, including five stone mace heads and limestone rings that were likely used as olive presses (Tufnell, 1958). Of interest is a worked piece of Kephren diorite that was likely mined in a quarry west of Toshka, Nubia, which is suggestive of early contact with Egypt (Tufnell, 1958). An ox metacarpal dating to the Upper Chalcolithic, was sawn off at both ends and had six holes bored into the shaft; it is suggested to be a musical instrument (Tufnell, 1958).

By the Early Bronze II (EBII), the cave dwellings of EBI were abandoned and subsequently used as communal graves by the unfortified settlement associated with EBIII and later. Internment style through most of the Bronze Age in Lachish consisted of multiple burials in caves. Grave goods of the period include juglets, copper pins, a dagger, ceramic, carnelian, steatite, and gold jewelry.

Archaeobotanical analyses of carbonized seeds from the site indicate that cereals and olives were abundant throughout the period, though the species of wheat were entirely Emmer or Eincorn in the EB, as opposed to Club or Bread Wheat found in the Iron Ages (Tufnell, 1958; Liphschitz, 2004).

The pottery of the Chalcolithic and EB in Lachish can generally be described as lime-washed, light brown or reddish kitchen, and domestic ware with a lumpy surface. Of the pottery documented, crude, hand-made cups are the most common form, but many types of ware including jars and basins were found (Tufnell, 1958; Ussishkin, 2004).

Middle Bronze (MB- ca. 2000-1550 B.C.E.)

A low density of pottery sherds and other material cultural items in the Middle Bronze I (MBI) stratum suggest an interruption in occupation or decrease in population density (Tufnell, 1977). The earliest evidence for resumed occupation are graves dating to the 18th century B.C.E. Included in one of these graves is a dagger inscribed with four known Canaanite symbols including the symbol for "human head", and is one of the earliest known attempts at alphabetic writing (Tufnell, 1977). A cemetery associated with Lachish and dated to the MB contained 16 shallow, rectangular and oval pits that were a combination of both single and multiple graves, and primary and secondary burials (Ussishkin, 2004). Many Egyptian scarabs and seals produced at Lachish were uncovered in MB graves and strata, indicating an increasing Egyptian influence in the period.

Pottery of different forms including pottery with base-rings, pot stands, and cooking pots attributed to the MB, which were entirely wheel-made, appeared in the archaeological record, and may represent the very beginnings of the true Canaanite culture (Tufnell, 1958). Imported ware and cultic vessels are also found and associated in the MB. The imported ware includes a juglet of White Painted IV form, a type common in Cyprus (Ussishkin, 2004).

Evidence for the construction of fortification works in Lachish attributed to the MB became apparent to excavators in 1932-33 while excavating the NW corner of the site mound. Typical Canaanite pottery sherds were accompanied by seemingly Egyptian and Mesopotamian sherds. Whether these sherds represent colonization, trade or merely cultural influence during this time is unknown. A destruction layer in Level VIII marks the end of the MB in Lachish (Mazar, 1992; Mazar et al., 1996).

Late Bronze (LB- ca. 1550-1200/1098 B.C.E.)

The Late Bronze (LB) in Lachish is often referred to as the time of the "Mighty Canaanite Civilization" (Tufnell, 1958; Mazar, 1992; Ussishkin, 2004). During the LB, specifically LBIII, Lachish was likely the largest Canaanite city-state in the south, and prospered under Egyptian hegemony as evidenced by Egyptian administrative documents, population growth, increased construction, and an increase in imported "luxury" goods (Ussishkin, 2004). Finkelstein et al. (2000) estimated that the territory of Lachish during the LB comprised 900km^2 and probably included at least 25 sites covering at least 30 hectares. Ussishkin (2004) asserts that using the coefficient of 200-people/inhabited hectare, the population of Lachish at this time could have been approximately 6,000 individuals (Ussishkin, 2004: 60). According to the archaeological record, the city and populace of Lachish during the LB advanced in all aspects of a city-state, which can be seen in the construction of temples and fortifications, foreign relations, trade, industry, and agriculture.

Construction. The LB in Lachish is typified in part by the construction of temples and increased fortification. Construction of the Fosse Temple, one of the most recognized temples in Syro-Palestinian archaeology, began in the LB. The temple underwent three recognized phases of construction, the first of which is denoted as Structure I of the LB. A fosse (a ditch or moat used in fortifications) and glacis (a slope extending down from a fortification) built in the MB as protection for the city was in ruins by the LB (Ussishkin, 2004). This fosse became the foundation and namesake for the famed temple. Structure I, the most basic of the three, contained two rooms and a sanctuary with a shrine consisting of a bench, altar, and hearth. Pottery, ivory objects, calcite and glass vessels, faience, jewelry, scarabs (scarabs royal affiliations range from the reigns of Thothmes III- Ramses II), and other seals, as well as cult objects and metal statuettes of deities were excavated in all three-construction phases of the temple (Tufnell et al., 1940).

Foreign relations. The LB in Lachish and all of Palestine is additionally characterized by Egyptian domination. Presumably, the increase in regional security facilitated the era of increased trade and prosperity in Lachish. The city prospered under Egyptian rule during the reigns of Thutmose III in 1468 B.C.E, and his successors Amenhotep II and III as evidenced by increased construction, imported wares and goods, and population growth (Tufnell, 1958). These kings are represented in the burial artifacts in many tombs of that period (Dothan, 1985; Wolff 1991, 1994, 1998). In the LB, natural and artificial caves were commonly used for burials, and were often circular with plastered walls.

Describing Lachish in the LB would be incomplete without referencing the Tell el Amarna Letters. The Amarna Letters were discovered in Akhenaten's Capitol, Egypt in 1887 (Moran, 1992). The letters are dispatches sent by Egyptian governors in Palestinian and Syrian cities and towns in the LB. They are written in Akkadian cuneiform, the writing system of ancient Mesopotamia and considered by many to be the regional language of diplomacy for this period (Moran, 1992). The known tablets currently total 382 in number and span a period of approximately 30 years. The messages in all of the letters have a similar tone; they are pleas for reinforcements and money to facilitate control of the local, restless populations threatening to overrun Egyptian rule abroad. In addition, the letters report many cases of murder, conspiracy, brigandage, and marauding bands of locals (Tufnell et al., 1940). Lachish was the location of dispatch for at least two of the letters, and is mentioned at least six times in several letters. Most of the references to Lachish are formal acknowledgements of orders received by Iabniilu and Zimridi, the Egyptian officials of Lachish (Tufnell et al., 1940).

Trade. Canaanite connections to the Mediterranean Sea facilitated increased trade relations in the LB. Port cities including Ashkelon, and the existing coastal trade relations of Egypt are manifested at Lachish by pottery, marine fish, mollusk bones, shells, and other goods from Egypt, north-western Anatolia, Mycenae, Crete, Cyprus, Syria, Lebanon, and north-western Arabia (Ussishkin, 2004).

Industry. There is evidence of a metal industry in Lachish in Level VI. This evidence includes fine, dusty waste from metallurgical activity, copper, tin, lead, and antimony concentrations in pigments; as wells as, plaster likely taken from locally smelted bronze ingots and objects, possible remnants of moulds and slags, and a large cache of broken bronze objects (Ussishkin, 2004).

Agriculture. Olives and olive oil continue to be extremely important staples in Lachish during the LB. Pollen analyses indicate that olive trees were more abundant in the LB than in the MB or Iron Age (Drori and Horowitz, 2004). Many flint sickle segments and a complete hafted sickle from the LB indicate extensive cultivation. The principle animals represented in the faunal collection of the LB are caprines (74.2%) and cattle (25.8%), although pig bones represent 1.50% of identified bovid remains (Croft, 2004).

Philistine pottery and Lachish. As previously mentioned in the Palestinian *Chronology* section of this chapter, Philistine Monochrome and Biochrome pottery are effectively absent from Lachish. A few sherds were found near a potter's workshop in a cave associated with Level VI, although Ussishkin (2004) believes them to be intrusive. This fact has far-reaching implications for Lachish and the chronology of all of Palestine. The coastal region of Palestine during the LB was the distribution center of Philistine pottery. Large quantities of Philistine pottery have been uncovered at sites between Lachish and the coastal distributive cities including Tel Zafit (Gaft) and Tel Miqne (Ekron). Both cities are major Philistine centers in the South and only 15 and 23 km north of Lachish.

Many sites more inland than Lachish contained Philistine pottery including Tel Beth-Shemesh, Tel 'Eton and Tel Beit Mirsim (Ussishkin, 2004). Given the size and importance of Lachish during the occupation of Level VI, many scholars (Ussishkin, 1985, 2004; Oren, 1985; Finkelstein, 1995a; Finkelstein et al., 2000; Yannai, 1996, 2004; Na'aman, 2000) find it unlikely that marine fish, mollusks, shells and other trade goods regularly arrived from the coastal cities without a single accompanying vessel of Philistine pottery. Furthermore, these scholars argue the implausibility of the prosperous nearby Philistine cities coexisting with Lachish during a time when Philistine pottery was diffusing inland from the coastal distribution centers without a substantial amount of that pottery reaching Lachish (consistent with the *Low Chronology*). Therefore, as Ussishkin (2004: 73) states:

> The only logical conclusion is that the absence of this distinctive pottery in Level VI shows that Lachish was simply not settled at the time that Monochrome and Biochrome Philistine pottery was being produced. Hence, the destruction date of the Level VI serves as a *terminus post quem* for dating the appearance of Philistine pottery in the Land of Israel (after the reign of Ramses III).

Most regional scholars (T. Dothan, 1982, 2000; Mazar, 1985; Singer, 1985; Stager, 1995; Bunimovitz and Faust, 2001), nevertheless, believe that Lachish VI was contemporary with at least the Monochrome pottery during the reign of Ramses III (consistent with the *Modified Conventional Chronology*) (See Chronology section in Ch. 2 for discussion).

The end of the Bronze Age in Lachish

As far as can be ascertained from material remains, Level VII is culturally continuous with Level VI; both represent the LB Canaanite culture (Ussishkin, 2004). At the end of the LB there is evidence of at least a partial destruction layer. The Fosse Temple (Structure III), a large central building, and the entire city area were burned. Unexpectedly, no evidence for a battle has been discovered. A scarab found during the British excavations bears the name Ramses IV (1151-1154 B.C.E), and is likely to have come from Level VI. Therefore, it is possible that the final date for the destruction of the LB city of Lachish was during or close to Ramses IV's reign (Ussishkin, 2004). Other cities in the region also have a destruction layer that may be contemporary with that of Structure III, including Tell Beit Mersim, and Tell Abu Hawam (Tufnell et al., 1940). Tufnell et al. (1940) and Ussishkin (2004) agree that the destruction of Structure III in Lachish corresponds with the collapse of the Bronze Age culture and Egyptian hegemony in all of Palestine (Tufnell et al., 1940; Ussishkin, 2004).

Archaeological data have yet to provide any evidence as to who destroyed Lachish (Ussishkin, 2004). Three possible peoples have been identified in the literature: an Egyptian Army, the Israelite tribes led by Joshua, or the Sea Peoples (Tufnell, 1958; Albright, 1935, 1937, 1939; Mazar, 1992; Ussishkin, 2004). Tufnell et al. (1940:44) states:

> But the chief evidence of destructive change at this time is the Cultural Revolution, which is so plain from the findings of archaeology. Some new

> factor is clearly at work, and unless the coming Israelites can be established in this period, the racial migrations recorded in the reigns of Meneptah and Ramses III, resulting in the settlement of the Philistines in the coastal plain, must be regarded as that factor.

The Iron Age (ca. 1200/1109-586/520 B.C.E.)

The Iron Age at Lachish is associated with stratigraphic layers V-II. Following the destruction of Level VI, Lachish appears to have remained abandoned for a long time. Finkelstein et al. (2000) concluded from archaeological and demographic evidence that the settlement locus during this time shifted to nearby Philistine city-states Tel Miqne (Ekron) and Tel Zafit (Gath), which likely prevented the re-settlement of Lachish during Iron I (Finkelstein et al., 2000; Ussishkin, 2004). The settlement of a new material cultural group, partially defined by red-slipped, irregularly burnished pottery vessels, becomes evident in Level V of Lachish, marking the beginning of the Judean kingdom and the settlement of the entire Shephelah by a new cultural group: the Judeans (Dagan, 2004; Ussishkin, 2004; Zimhoni, 2004).

A decrease in imported goods in the archaeological record of the Iron Age at Lachish compared with the Bronze Age suggests a reduction in commercial and cultural connections with the Coastal Plain (Lernau and Golani, 2004; Ussishkin, 2004). As detailed by Lernau and Golani (2004), 184 Nile perch bones were discovered in LB contexts compared with 15 in Iron Age contexts, 62 bones of sharks and rays vs. 4, and 47 bones of sea bass vs. 14. Ussishkin (2004) attributes this reduction as a function of the acute political changes between the Bronze and Iron Age in Palestine. During the Bronze Age, Lachish was a powerful Canaanite city-state with strong connections to the Canaanite cities and foreign trading partners of the Coastal Plain. During Levels IV-III Judean Lachish held political and economic affiliations with Jerusalem, as evidenced by the vast majority of pottery affiliated with Judah compared to only a handful of Coastal pottery, while the Coastal Plain was dominated by Philistia (Tufnell, 1958; Ussishkin, 2004).

Subsistence during the Judean kingdom period was achieved through the manufacture of olive oil and wine, and the cultivation of cereals. The recovery of carbonized grape vine remains, the portrayal of massive grape vines on the Assyrian Lachish Reliefs, several stone and clay wine stoppers uncovered in Level III storerooms, and Hebrew inscriptions on the shoulders of decanters recording the types of wines stored in them, attest to the importance of wine production in Lachish (Ussishkin, 1982; Zimhoni, 2004). Even today, the region is known for producing Israel's best grapes and wine (Ussishkin, 2004: 94).

Significant changes in agricultural tools and cereal production were afforded by the development of iron technology. Iron ploughs, sickles and other agricultural tools were uncovered in the houses and buildings of Level III at Lachish (Tufnell, 1958; Ussishkin, 2004).

The faunal collection from the Iron Age is smaller than that of the Bronze. Caprines (71.8%) and cattle (28.2%) still dominate the assemblage, though the percentage of pig bones decreased from 1.50% of the Bronze Age collection to .60%

(Croft, 2004). Chicken bones were uncovered in a Level IV house, which is significant, as no evidence of domestic fowl had ever been found in Bronze and Iron strata in Israel prior to this discovery (Ussishkin, 2004).

Lachish, during the Iron Age became the military stronghold of Judah in the south, while Jerusalem protected the Judean kingdom in the north (Mazar, 1992). The Iron Age at Lachish is further summarized below according to artifacts and architecture per stratigraphic level.

Level V. Very little is understood about the settlement of Level V. As is the case with many sites of the Iron Age in Palestine, much controversy surrounds the dating of these Early Iron Age strata. The controversy essentially mimics the chronology debate for all of Palestine: a Biblical controversy. Many archaeologists (Aharoni and Amiran, 1958; Yadin, 1980; Dever, 1982, 1986; Mazar, 1997; Mazar and Panitz-Cohen, 2001) attribute Level V at Lachish to the period of the United Monarchy of Solomon and David in the early part of the 10th century (*Modified Conventional Chronology)*, thus connecting Judean Lachish with a biblical passage in the book of 2 Chronicles 11:5-12,23 where Lachish is said to have been fortified by Rehoboam, the son of Solomon and a grandson of David who was the initial king of the United Monarchy of Israel, and eventually the king of the Kingdom of Judah. Parties on both sides of the controversy use pottery to assess a date for the stratum, as the assemblage attributed to Level V is presently the only chronological indicator available (Ussishkin, 2004). Based solely on comparisons between pottery assemblages of Levels V to that of Level's IV and III (which are dated confidently), Zimhoni (2004) estimates that the Level V assemblage would fall in the first half of the ninth century B.C.E. (supporting the *Low Chronology*).

Level IV. The ancient city of Lachish, Level IV is characterized by construction of massive fortifications (Ussishkin, 2004). They include city walls, towers, buttresses, a large city gate, and a Palace-Fort with auxiliary buildings at the center of the enclosure. These fortifications are considered the largest and most comprehensive of their kind excavated in Israel (Ussishkin, 2004). Jamieson-Drake (1991) suggests that as public works are indicators of high-level administrative control systems, these fortifications and constructions are likely suggestive of a chiefdom or state.

The city of Level IV came to a sudden end, reportedly due to an earthquake. Evidence for an earthquake as the terminal event for Level IV is as follows: 1) no significant ash layer was uncovered for this period; 2) the Palace-Fort, Enclosure Wall and parts of the gate-complex were rebuilt in Level III along the same lines as the original structures; 3) material culture appears to be continuous between Levels IV and III; 4) evidence for an earthquake is supported at other sites in the region at the same period (Dever, 1992; Austin et al., 2000; Ussishkin, 2004).

Level III. The beginning of Level III is marked by the reconstruction of many elements of Level IV. The mud brick Enclosure Wall was rebuilt with massive stones, the drain beneath the gatehouse was replaced, and the Palace Fort was rebuilt and greatly expanded (Ussishkin, 2004). The rebuilding and construction at the beginning of Level III indicate a period of expansion and activity in Lachish.

The royal Judean storage jars are a series of jars that likely stored wine and/or olive oil that have been stamped by the official royal Judean seal accompanied with the name of a king or an official. In all, a total of 489 specimens have been uncovered at Lachish, 413 of which are the royal jars called *lmlk* jars, and 76 private jars without the royal stamp (Ussishkin, 1976, 1977, 2004). All of the stamped jars were uncovered in Level III. *lmlk* represents the Hebrew letters *lamedh mem lamedh kaf* , which can be translated from Hebrew as 'belonging to the king' (Grena, 2004). Stamps on the jars are important for the reconstruction of events and reigns of kings in all of Judah. The collection from Lachish is the largest and best-preserved in all of Israel (Ussishkin, 2004).

Destruction of Level III came at the hands of the Assyrian King Sennacherib in 701 B.C.E. Evidence for this destruction is plentiful and can be categorized into three types of sources: 1) Written evidence directly referring to Sennacherib's attack on Lachish from the Bible and the Assyrian annals describing the attack, 2) The large-scale excavation of Level III which exposed the remains of the attack and Syrian conquest, and 3) The Lachish reliefs excavated in Nineveh, Assyria (modern day Iraq) depicting the conquest (Ussishkin, 1977, 1980, 1990, 2004).

The attack and conquest of the city was devastating. Archaeological evidence for the battle is conclusive and extensive, allowing for the analyses of numerous aspects of the battle including dates, siege and defense strategy, and engineering and military tactics (Gottlieb, 2004). Remnants of the attack include two siege ramps to overcome the city's fortifications, over 1500 arrowheads concentrated in the two points of Assyrian attack (many of which are embedded in masonry), over 150 sling stones found both inside and outside the city walls, as well as spears, armor scales, large boulders that crushed through parts of the siege ramp, and a thick burn layer (Tufnell, 1977; Ussishkin, 1977, 1980, 1982, 1990, 1993, 2004; Sass and Ussishkin, 2004; Gottlieb, 2004). As depicted on the Lachish reliefs, once the Assyrians were inside the city, they executed Judean officials, deported the populace, and then burned the city (Ussishkin, 1977, 2004).

Level II. Level II begins with a settlement gap following Sennacherib's conquest. A re-settlement and construction period commenced during Level II, and is assumed to have begun after the collapse of Assyrian rule in the country, sometime in the last part of the seventh century B.C.E. (Na'aman, 1991; Ussishkin, 2004). The Level II settlement was poorer and more vulnerable than the Level III predecessor as is evidenced by smaller scale fortifications, sparsely occupied residential areas, and a single public building (compared to dozens in Level III) (Tufnell, 1953; Ussishkin, 2004).

An extensive ash layer marks the end of Level II. This layer is generally accepted to be the remnant of the conquest of Lachish by Babylonian king Nebuchadnezzar and his army around 588/6 B.C.E. (Torczyner et al., 1938; Tufnell, 1953; Ussishkin, 2004). Besides two 'Scythian' type arrowheads and the ash layer itself, there is little archaeological evidence that can be attributed to an attack. The main line of evidence comes from the 'Lachish Letters', which are a series of Hebrew inscriptions on fragments of a single storage jar sealed in the destruction debris of

Level II. The inscriptions provide details of the Babylonian conquests of the remaining Judean cities, including Lachish and Azekah (Torczyner et al., 1938; Tufnell, 1953; Emerton, 2001; Lemaire, 2004). The Babylonian conquest marks the end of the Iron Age in Lachish. The city was reoccupied in the Persian Period, abandoned shortly after, and then re-settled on a small scale, likely for agricultural purposes throughout the following Roman, Byzantine, and Moslem Periods (Starkey, 1936; Tufnell, 1953; Amiran and Dunayevsky, 1958; Aharoni, 1968; Ussishkin, 2004).

Who are the peoples of ancient Lachish?

As mentioned, the Biblical city of Lachish was considered the second most important city in Judah, and for most of its existence was a 'Canaanite royal city' (Mazar, 1992). Archaeological stratums IV-II (Iron Age) are of great interest due to their association with numerous archaeological, biblical, and Assyrian textual data. To re-cap, the city is mentioned in the el-Amarna letters, in a letter discovered at Tell el-Hesi, several times in the Bible, and is named there as one of the five cities of the coalition that fought Joshua and lost. Lachish is considered by many to be a prize of the 'Israelite Conquest', the story from the book of Joshua, depicting the 12 tribes of Israel traveling through Palestine destroying many of the Canaanite cities and annihilating much of the population (Wright, 1955; Tufnell, 1977; Ussishkin, 1977; Rainey, 2001; Joshua 10:5; Numbers 328, 329, 332; II Kings 14:19; II Chronicles 25:27; Isaiah 36). From an archaeological standpoint, the conquest in Palestine is not supported (Dever, 1997). Of the many cities mentioned in the conquest narrative that have been located and excavated, only two -- Bethel near Jerusalem and Lachish in Judah -- have a destruction layer c. 1200-1100 B.C.E that could be associated with the conquest (Kelso, 1968).

Many historic and contemporary archaeologists have interpreted the archaeological record through the Biblical Old Testament (Albright, 1939; Stager, 1985; Redford, 1992; Mazar, 1992, 1997, 2005; Holladay, 1995; Dever, 1995a,b,c, 2001). Many, however, have sought to interpret the archaeological record with limited or without a Biblical context (Keita, 1988; Finkelstein, 1995a, 1996; Ussishkin, 2004; Ullinger et al., 2005). As a result of the differing interpretations, Lachish and its ancient inhabitants are surrounded with controversy. Currently, there are many hypotheses accounting for the identity of the Late Bronze and Early Iron Age inhabitants. All of the hypotheses can be summarized as either supporting biological continuity or replacement. Outlined here are four common hypotheses proposing the identity of the Lachish Late Bronze and Early Iron Age inhabitants based on archaeological, bioarchaeological and textual evidence:

1. "The Israelite Conquest"-**(replacement).** Skeletons of the Late Bronze Age represent defeated Canaanites and the Early Iron Age skeletons represent individuals of the 'Israelite Conquest' who came to occupy Lachish (Albright, 1939; Stager, 1985; Redford, 1992; Holladay, 1995). This hypothesis is based on the evidence of destruction layers in the two sites of Bethel and Lachish during the Late Bronze Age in Ancient Palestine. The destruction layers combined with varied evidence of cultural transition during the same period are taken to confirm the

"Israelite Conquest" story from the Book of Joshua in the Bible. Lachish is named in Joshua as one of the five cities of the coalition, destroyed by the twelve tribes of Israel moving through Palestine and destroying many of the Canaanite cities (Wright, 1955; Tufnell, 1977; Rainey, 2001; Joshua 10:5; Numbers 328, 329, 332, *ibid* 10:26, 32-33, 15:39; II Kings 14:19; II Chronicles 25:27; Isaiah 36).

***2. "Victims of Battle"-* (continuity).** The Early Iron Age skeletal collection is comprised of victims of a battle with Assyria that likely took place at Lachish in 701 B.C.E. (Tufnell, 1953; Ussishkin, 1982, 1990; Mazar, 1992;). A series of stone reliefs discovered by Layard (1853) portray a great battle in which Lachish is defeated by Assyrian King Sennacherib and his army in 701 B.C.E. The reliefs depict men, women, and children being captured, led away, and killed by the Assyrians (Starkey, 1936; Tufnell, 1950, 1953; Ussishkin, 1980, 1990; Davies, 1982, 1985; Blakely and Horton, 2001). Based on the reliefs and other observations, excavators and scholars believed that the skeletal remains of tombs 107, 108, 116, 117, and 120 contained victims of the attack (Tufnell, 1953; Ussishkin, 1982, 1990; Mazar, 1992).

***3. "Immigration"-* (replacement).** The skeletons of the Iron Age collection represent an unknown immigrant group (Israelite, Egyptian, Philistine, etc.) who replaced the previous Canaanite Bronze Age population (Risdon, 1939; Finkel, 1976, 1978; Redford, 1992; Dever, 1995a,b). Dever (1995a) reports a significant "ethnic" division between individuals of the Late Bronze Age (Canaanites) and Iron Age (Israelites) (Dever, 1995a). He asserts that Israelites were nomadic pastoralists from southern Transjordan (mentioned in the Amarna documents), who immigrated to the hill country, returning to an agrarian lifestyle during the Early Iron Age, and replacing many Canaanite populations (Mazar, 1992).

***4. "Biological Continuity"-* (continuity).** The Iron Age individuals in the collection represent descendants of the Late Bronze Age individuals, suggesting that any cultural change can be explained by changing political, economic, and social circumstances in Ancient Palestine as a whole (Finkelstein, 1995b, 1996; Ussishkin, 2004; Ullinger et al., 2005). This hypothesis posits that a cultural transition in the region does not reflect a biological transition. Change is seen as a slow and complex movement involving cultural and biological assimilation between Canaanites and Israelites (and depending on the region, possibly Egyptians, Philistines, Phoenicians, Samarians, and the Sea Peoples) over many generations (Finkelstein, 1995b, 1996; Ussishkin, 2004; Ullinger et al., 2005).

Affinity Studies in Lachish and surrounding regions

The skeletons from the Late Bronze Age and Early Iron Age excavated in the 1930's at Lachish are now housed at the Natural History Museum in London, England. Over the years, the remains have been studied in order to support either biological continuity or replacement between the individuals of the Bronze and Iron Ages; these studies are summarized below. Included are brief reviews or comments concerning affinity studies done on other relevant populations. These settlements were included because either they are in close proximity to Lachish and may represent similar populations, or because they have been indicated as possible biological contributors within the broader region.

In 1939, DL Risdon published the first report on the skulls of the Lachish collection, including an assessment of demography, pathology, metrics, artificial deformation, and biological affinity. Based on this analysis, Risdon disagreed with the "Victims of Battle" theory, claiming he found only one male skull with life threatening trauma (probable sword hacks). He instead proposed that they were perhaps killed by a natural disaster or devastating pestilence (Risdon, 1939). However, slight trauma may have gone unnoticed, not to mention the fact that 80% of the skeletal collection is comprised of crania, possibly explaining the lack of observable trauma. Risdon (1939) concluded from his biometric studies of the crania, that the individuals were most similar to dynastic Egyptians. Furthermore, he reported that the entire collection was likely not indigenous, representing a group derived from Lower Egypt, thus supporting the immigrant hypothesis.

Giles (1953) compared craniometric data from the Lachish Bronze Age collection to Risdon's (1939) Iron Age data in order to determine if a significant difference between the two groups existed. Giles concluded that while the Bronze sample size was not adequate for sufficient statistical comparison to the larger Iron sample, her data did not provide reason for stating that the Bronze Age sample differed from the Iron Age sample (Giles, 1953).

The results of Musgrave and Evan's (1981) craniometric study supported Risdon's (1939) Egyptian suggestion. A few years later Keita (1988) performed metric analyses on the skulls by means of 13 multiple canonical variants used as discriminate functions. He omitted individuals that were female, juvenile, artificially deformed, warped, and/or split following the procedures specified by Howells (1973). He concluded that the collection was largely heterogeneous, having close affinity to North African, Egyptian, and Nubian groups, thus claiming the Lachish collection to have an "Egypto-Nubian presence" (Keita, 1988: 388; Ullinger et al., 2005).

Berry and Berry (1972), using non-metric cranial analysis, found that the Lachish series was significantly different from Egyptian collections. They did not elaborate on the Lachish collection, as the main analysis was focused on Egyptians, but determined that the crania differed significantly from an Egyptian 'type' (Berry and Berry, 1972: 199).

Finkel (1976) used craniometrics on a "Middle Eastern Cranial Series" including Turkish, Syrian, Egyptian, Iranian, and Palestinian (including Lachish) skulls to assess affinity between populations. He found that the broad region did not display characteristics of a single breeding population, and that even within each group he found a certain level of heterogeneity. Furthermore, in the Lachish collection he reported marked differences between the Bronze and Iron Age collections, seemingly supporting an immigration or conquest hypothesis.

Ullinger et al. (2005) performed dental non-metric analyses on the Lachish and Dothan collections using 17 of the 36 ASUDAS traits; thus far, it is the only dental analysis published on these groups. Ullinger and colleagues' results indicate significant homogeneity and biological continuity in the Late Bronze-Early Iron Age transition in the southern Levant. The close affinity between Tell Dothan and Lachish suggests the two are more closely related to each other than to other groups in the Mediterranean region, and that material cultural change was not a consequence of immigrant replacement (Ullinger et al., 2005). The conclusions of Smith's (1989) study using nonmetric cranial shape analysis are similar, arguing that Levantine populations of the Bronze and Iron Age (including Megiddo, Bir Safadi, Abu Gosh and Ben Sheman) show remarkable biological homogeneity (Arensburg, 1973; Arensburg et al., 1980; Smith, 1989).

Based on the affinity work undertaken on the remains at Lachish and the surrounding regions, the identity of the inhabitants and where they fit into a larger geographic context is inconclusive. Most of the aforementioned studies rely on craniometrics to assess affinity. Using craniometrics alone in affinity studies can be problematic due to the susceptibility of skeletal material to taphonomic processes. In addition, approximately 5% (Ullinger et al., 2005: 469) of the Lachish skulls exhibit cranial deformation, a further hindrance to metric analysis. Lastly, many of these studies are dated and use non-standard techniques and statistical procedures.

For the reasons highlighted above and discussed in the next chapter, dental nonmetric affinity analysis is an appropriate method to address whether material culture changes between the Late Bronze and Early Iron Age inhabitants of Lachish are the result of: 1) immigrants settling the region, or 2) an in situ evolution of practices by the same indigenous peoples. Moreover, the methodology addresses whether the ancient Lachish populace is phenetically similar to other groups in the Mediterranean Diaspora, and if so, identifies groups with which they have a greater biological affinity. Building on the work of Ullinger et al. (2005), a bioarchaeological approach is used to test hypotheses concerning biological continuity or replacement during the Bronze/Iron transition. The present research expands on Ullinger et al. 2005 by including an increased number of specimens, a larger suite of dental traits (36 as opposed to 17), and a much larger comparative collection to ascertain the affinity of the Lachish sample.

CHAPTER 4- METHODOLOGICAL BACKGROUND

Dental Anthropology

As a subfield of biological anthropology, dental anthropology is defined as the study of humans and their closest relatives as evidenced by their teeth. Dental anthropology is largely associated with bioarchaeological investigation and incorporates techniques of other fields, including dentistry, forensics, genetics, anatomy, and paleontology.

The study of human teeth, from the anatomist's perspective, is anchored in normative tooth structure and form. For the anthropologist, the focus is on subtleties and variation in tooth structure, size, and form. Variation in phenotype of the dentition can arise for several reasons including genetics, maternal health, dental ontogeny, diet, and the environment. Despite the fact that teeth can be influenced by and directly interact with the environment, and excluding pathological considerations, the size, form, and morphology of teeth are primarily determined by one's genes (Turner, 1967; Scott, 1973; Berry, 1974; Larsen, 1997; Scott and Turner, 1997). Twin studies have shown that genetic influence accounts for 60-90% of both tooth size and morphology, depending on tooth class or dental trait (Lundstrom, 1967; Biggerstaff, 1969, 1973; Scott and Potter, 1984; Townsend, 1992; Dempsey and Townsend, 2001). Given the high genetic component, studying specific variability in tooth form and morphology can provide insight into variation at the macroevolutionary (between and among species), and microevolutionary (within, between and among populations) levels (Turner, 1969; Hawkey, 1998).

Microevolutionary research and dental analysis

Microevolutionary research is driven by analyzing evolutionary change within species based on identifying evolutionary processes of natural selection, genetic drift, mutation, and gene flow. Researchers conducting affinity studies seek to estimate biological distances between, among and within populations based on polygenic skeletal and dental traits (Campbell, 1925; Buikstra et al., 1990; Edgar, 2007; Bernal et al., 2009, 2010).

'Population' as used here, can be defined as a community of interbreeding individuals who occupy the same general area and are influenced by the same environmental factors (Campbell and Reece, 2002). In dental analysis, differences in dental morphology observed between populations are explained as the result of one or more of the evolutionary forces. The degree of relatedness assumes populations who share many attributes are more closely related than populations with many observed differences (Turner, 1969; Irish and Turner, 1989). On a global scale, crown and root traits show distinctive patterns of geographic variation. Inter- and intra-population affinities are identified through the simultaneous analysis of multiple traits via any number of multivariate, univariate and/or descriptive statistical analyses (Constandse-Westermann, 1972; Sjovold, 1973; De Souza and Houghton, 1977; Blangero and Williams-Blangero 1991; Irish, 1993, 1998 a,b,c, 2000, 2005, 2006, 2010; Hanihara 1994; Hillson, 1996; Bedrick et al., 2000; Irish and Guatelli-Steinberg, 2003; Harris and Sjovold, 2004).

Dental analysis of microevolutionary patterns and biodistance estimates can be categorized into two broad types of study: dental metric and dental morphological. Neither metric nor non-metric traits possess a one-to-one genetic correspondence or known modes of inheritance. Generally, a polygenic mode of inheritance with a quasi-continuous range of expression is most accepted (Turner, 1967; Dahlberg, 1971; Goose and Lee, 1971; Scott, 1973; Berry, 1978; Biggerstaff, 1973; Nichol, 1990; Scott and Turner, 1997), and while more research concerning modes of inheritance is necessary, a complete understanding of these processes is not crucial to perform affinity studies (Irish, 1993).

Dental morphological study. The field of morphometrics is characterized by the description and statistical analysis of the variation in shape within and among samples of organisms and of the analysis of shape change as a result of growth, experimental treatment or evolution (Rohlf and Marcus, 1993; 129). Specifically, dental morphologists study the structure and form of teeth. The structure and form of human teeth, as previously mentioned, are under strong genetic control and are possible indicators of population biological affinity.

Dental morphological study entails the examination of specific nonmetric features of crowns and roots of teeth. Nonmetric traits are discrete anatomical entities that manifest in varying degrees of expression between, within and among populations making them ideal for biodistance and affinity studies (Campbell, 1925; Shaw, 1931; Garn et al., 1965; Berry, 1978; Townsend and Brown 1978; Scott and Turner, 1988; Nichol, 1990). By determining frequencies of occurrence and expression and then comparing the resulting data statistically, one can infer the degree of relationship between samples.

As early as the 19th century, anatomists and naturalists were describing morphological variations in human teeth and associating that variation with ethnic complexes. In 1842, Georg Von Carabelli wrote of an accessory mesiolingual cusp on the upper molars of European individuals (Kraus et al., 1959). By the beginning of the 21st century, dental morphology began receiving more scholarly attention. Ales Hrdlicka (1920) was the first to describe and classify the degree of expression of a morphological trait (shovel shaped incisors) and to assess variation of the trait among several human populations, as well as non-human species. His findings indicated a close similarity between the teeth of Asians and Native Americans (Hrdlicka, 1920). Researchers such as T.D. Campbell (1925), M. Hellman (1928) and J.C.M Shaw (1931) were making detailed observations about dental morphology including cusp number, groove pattern, and root variations, while urging physical anthropologists to place more emphasis on the study of dental variation.

In 1940, Albert A. Dahlberg, a dentist, began researching and publishing on dental morphology in various ethnic groups, including Pima Native Americans. Dahlberg released a series of reference plaques, dental casts and pedigrees, in 1956 in an attempt to standardize observations on various morphologies of teeth. In the 1950's and 1960's, researchers including S. Garn, K. Hanihara, and P. Pedersen contributed to the growing body of work on the genetics and morphogenesis of tooth crown traits. Hanihara (1963) developed a series of reference plaques similar to those of Dahlberg for deciduous teeth and it became apparent that broad-scale standardization was needed in order to compare the work being done in dental morphometrics. In 1991, Christy Turner II and colleagues at Arizona State University developed a comprehensive series of plaster plaques and scoring forms for permanent teeth. The series was named The Arizona State University Dental Anthropology System (ASUDAS) and is the most widely used and recommended standard in nonmetric dental morphology (Scott and Turner, 1988; Turner et al., 1991; Hillson, 1996). For a detailed description of traits used in the ASUDAS, see Appendix 3.

Turner's research helped to establish "odontographies," i.e., dental morphological studies of particular ethnic groups. These studies have led to the development of dental complexes or collections of dental features held in common by specific, large ethnic groups (Hillson and Antoine, 2003; Irish and Nelson, 2008). These complexes are based on "permanent" teeth, though there have been several deciduous dental analyses as well (Keiser, 1984; Kitagawa et al., 1995; Adachi et al., 2003; Lease, 2003; Aguirre et al., 2006).

In addition to the standard methods for gathering non-metric morphological data, specific varieties of statistical analyses are standard as well. Inter- and intra-population affinities are identified through the simultaneous analysis of multiple traits via any number of multivariate, univariate and/or descriptive statistical analyses including Mahalanobis D^2 and the C.A.B. Smith Mean Measure of Divergence (MMD), both of which are commonly used with nonmetric data (Irish, 2010). Many of these statistics involve the determination of principal components analysis, discriminate function, biodistance statistics, and cluster analysis or multidimensional scaling to identify relationships (Constandse-Westermann, 1972; Sjovold, 1973; De Souza and Houghton, 1977; Blangero and Williams-Blangero 1991; Irish, 1993, 1998 a,b,c, 2000, 2005, 2006, 2010; Hanihara 1994; Hillson, 1996; Bedrick et al., 2000; Irish and Guatelli-Steinberg, 2003; Harris and Sjovold, 2004).

Over 100 different morphological dental traits have been observed the in human dentition (Scott and Turner, 1997). Currently, over 35 nonmetric traits are well defined and have been standardized to be used in biodistance analysis. These traits include discrete crown attributes (e.g. Carabelli's trait, incisor shoveling), and root variations (e.g. lower molar root number, radical number). Dental osseous traits that are considered useful for biodistance analysis include the palatine and mandibular tori and the rocker jaw among others (Turner et al., 1991; Irish, 1993). Because of the high genetic component and conservative nature of their evolution, nonmetric dental traits are important tools in biodistance analysis. For a detailed account of the prescribed dental morphology of geographic populations, see Scott and Turner (1997).

Advantages of using teeth as a research tool

Several qualities inherent in the animal dentition make teeth a valuable research tool. First and foremost, teeth are the best-preserved biological component in the archaeological and fossil record, often resulting in a large sample size (Klein, 1987). This is likely due to the fact that the enamel covering the tooth crown contains a large percentage of mineralized calcium hydroxyapatite, which exhibits the lowest porosity and highest density of all skeletal tissues (Kraus et al., 1969; Robinson et al., 1986). Second, teeth are the intermediary between the individual and the environment, leaving many and varied discernable clues about diet, health, and the cultural use of teeth (Molnar, 1972; Cybulski, 1974; Vogel and van der Merwe, 1977; Merbs, 1983; Frayer et al., 1988; Larsen, 1985, 1997; Benfer and Edwards, 1991; Molleson and Jones, 1991; Katzenberg, 1993; Katzenberg and Pheiffer, 1995; Schweissing and Grupe, 2003; Pye and Croft, 2004). Thirdly, individually and in the dentition, teeth are complex and show a largely consistent range in size within species and sex (Scott, 1973; Smith and Shegev, 1988; Bermudez de Castro, 1989; Turner et al., 1991; Irish, 1993; Scott and Turner, 1997). Fourth, evolutionarily, teeth tend to be conservative rather than plastic through time and have a high genetic component in structure and form (Turner et al., 1991; Irish, 1993; Scott and Turner, 1997). And finally, teeth can be studied and compared among living and dead populations allowing inferences to be made about relationships between the “extinct and the extant” (Irish, 1993:5). Thus, teeth can provide the researcher with insights into many genetic, developmental, behavioral, cultural, pathological, and environmental insights, making them preferred subjects of biological inquiry.

Disadvantages of using teeth as a research tool

While there are many advantages to using teeth as a research tool, there are several inherent disadvantages associated with studying the dentition: Firstly, information can be lost through dental wear and pathology, both of which can be common because of the age of the individual and/or post-depositional damage. Second, the precise modes of inheritance of most traits are unknown. Thirdly, global ranges of dental variation are not completely known. Fourth, the negative effect asymmetry may have on the expressivity of a trait can be troublesome in the analysis, but can be avoided during the data collection process (see methods section for a detailed explanation). And fifth, dental traits are continuous variants, and as such, are difficult to score consistently, and could be evaluated based on personal opinion or school of training (Turner et al., 1991; Hillson, 1996), although careful adherence to the ASUDAS protocols and intra-observer error trials and statistics can minimize the disadvantageous effect.

Current Dental Morphological Methods

The ASUDAS, as mentioned, is the most widely used method for assessing nonmetric morphological variation. In the definitive textbooks *Bioarchaeology* by Clark Larsen (1997) and *Dental Anthropology* by Simon Hillson (1996), the ASUDAS is the only method employed throughout dental morphological studies (for a full description of ASUDAS, see Turner et al., 1991 and Scott and Turner, 1997). The methods that developed into the ASUDAS began in Western Europe and diffused to America, Japan, South Africa and other areas of the world.

Dental morphologists have traditionally used non-standard methods that are both differing and similar to ASUDAS. These methods may include observations on real teeth or models of teeth, emphasizing positive structures (e.g. cusps, tubercles, etc.), and focusing on presence/absence (Scott and Turner, 1997). Alternative techniques have been developed that encompass one or all of those methods, but have not been widely adapted or used. Researchers may choose to score crown and root traits without using the standardized system, thereby making their research and conclusions nearly incomparable with other studies and data sets. Thus, the ASUDAS is the most useful and only widely used method for the scoring and evaluation of nonmetric dental features. Using a series of standardized plaques minimizes inter- and intra-observer error and encourages the use of a common terminology. Only traits that have been associated with genetic heritability are included in the system (Nichol and Turner, 1986; Scott and Turner, 1997).

Irish (1993, 1997, 1998 a,b,c, 2000, 2005, 2008; Irish and Guatelli-Steinberg, 2003; Irish and Konigsberg, 2007) has been documenting morphological variation in Africa for two decades. He has built and continues to build an extensive database of morphological variation data from many world populations. Irish and Guatelli-Steinberg (2003) in a recent nonmetric study found that out of all modern humans they sampled, sub-Saharan Africans exhibit the closest phenetic similarity to African Plio-Pleistocene hominin. F. Ricaut and colleagues (2010) did a comparative study between genetic and nonmetric data for the same individuals excavated from the Egyin Gol necropolis, Mongolia. Affinity matrices based on nonmetric and genetic data were correlated demonstrating the potential of nonmetric traits for estimating affinity in the absence of genetic data.

Continued morphological documentation of all world populations, living and dead, coupled with genetic studies aimed at the same groups will eventually uncover more genes underlying dental phenotypes and stronger heritability figures. As ancient DNA is often degraded and/or contaminated, is destructive to extract and can be expensive to analyze, dental morphology is a reliable tool in assessing biodistance among or within populations. The polymorphic features of the dentition behave like other biological variables that anthropologists use to assess population history and evolution. The dental traits carried with humans, like blood groups or fingerprint patterns, are passed down to the next generation. They are affected by one or more of the forces of evolution which can be observed in extant populations and in the fossil and archaeological record, making these traits ideal for short and long term hominin evolution study (Scott and Turner, 1997).

CHAPTER 5- MATERIALS AND METHODS

Materials: Samples used in study

The Lachish skeletal collection is comprised of 776 individuals. Of the 776 individuals examined, 399 had at least one scorable trait. The permanent dentitions of 399 individuals including those adults who could be observed for the presence of oral tori and rocker jaw comprise the two samples compared in the present study. The Bronze (n=34) and Iron Age (n=365) individuals that possessed permanent teeth or vestiges thereof of the Lachish Skeletal Collection were analyzed and scored for 36 discrete dental traits, including two oral tori and rocker jaw. Additional summary data including tomb designation for both samples and sex percentages are presented in Tables 3 and 4.

Table 3. Age and sex distribution of Bronze and Iron Age individuals

	Bronze Age	**Iron Age**	**Totals**	
			total	% total
Adult male	13	187	200	50.1%
Adult female	12	144	156	39.1%
Sub-adult	9	34	43	10.8%
Total	**34**	**365**	**399**	100%

Table 4. Distribution of individuals

Tomb Number	Period	Number of individuals
239	Bronze Age	1
501	Bronze Age	1
508	Bronze Age	1
508-A	Bronze Age	1
4002-A	Bronze Age	1
4005	Bronze Age	9
4029	Bronze Age	2
6006	Bronze Age	1
6009	Bronze Age	1
6009-A	Bronze Age	1
6009-C	Bronze Age	1
6013-G	Bronze Age	1
6013-L	Bronze Age	1
6027	Bronze Age	2
6027-B	Bronze Age	1
6028-A	Bronze Age	1
6028-B	Bronze Age	1
6028-D	Bronze Age	1
6028-E	Bronze Age	1
6028-F	Bronze Age	1
6028-G	Bronze Age	1
6028-H	Bronze Age	1
6028-J	Bronze Age	1
6028-L	Bronze Age	1
106	Iron Age	7
107	Iron Age	16
107-B	Iron Age	25
107-C	Iron Age	3
108	Iron Age	1
108-B	Iron Age	2
116	Iron Age	31
120	Iron Age	257
128	Iron Age	1
189	Iron Age	1
216	Iron Age	3
218	Iron Age	6
223	Iron Age	1
224	Iron Age	5
521	Iron Age	1
1002	Iron Age	1
2105/2470	Iron Age	1
220	Historic	1
DPAL	Unknown	1
Unknown	Unknown	1
Total		**399**

Iron Age Skeletons. The majority of the Iron Age individuals in the collection were excavated from four interconnected, naturally occurring cave internments: Tombs 107, 108, 116, 120 (Figure 3). Tomb 107 was the first to be opened and yielded 500 human skeletons damaged by fire. The adjoining Tomb 120 was located, revealing approximately 1500 individuals. The remains were disarticulated with the majority of skulls piled against the sides of the chamber. Crania represented the majority of skeletal elements recovered; however, a limited number of mandibles, long bones and other post-cranial material were excavated as well. All remains from the four tombs were dated to the Early Iron Age based on pottery and Egyptian artifacts intermixed with the skeletons. Of the remains excavated, approximately 700 well-preserved skulls and several mandibles, long bones and vertebrae were selected to be shipped to England. Males account for 51.8% of the sample sent to England, with females accounting for 39.4% and juveniles and infants accounting for 8.8% (Risdon, 1939: 103). Risdon (1939) concluded that the representative population was considerably younger than the interred of most ancient or modern cemeteries, with few aged specimens in the collection; however, these observations may have been an artifact of the chosen sample.

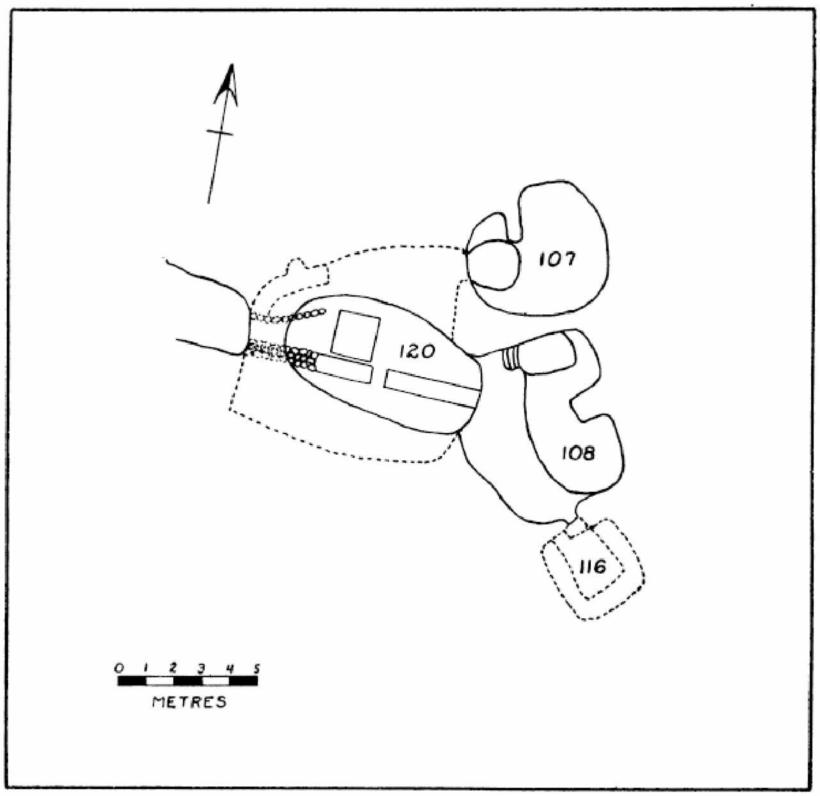


Figure 3. Plan of the tombs at Lachish from which the Iron Age human remains were recovered. The dotted lines represent the floor area of Tomb 120, and the outline of the benches (inner line) and the maximum perimeter of Tomb 116 (Risdon, 1939: 101).

Bronze Age Skeletons. Members of the Wellcome-Marston Expedition excavated the Bronze Age skeletons at approximately the same time as the Iron Age individuals (Risdon, 1939). The tomb types and construction, pottery sherds and grave artifacts differed from those of the following period (Risdon, 1939; Eph�al, 2009). Due to a lack of records concerning the excavation, tombs and analyses of these late Bronze Age individuals, little else is known about the collection.

Comparative Samples. Comparative samples (26 samples, n=1,349 individuals) from European and African groups (Figure 4) used to estimate biological affinity of the Lachish sample within the Mediterranean area, as well as Egypt and Nubia, were personally collected and/or assembled by Joel D. Irish in a global database of non-metric dental morphological data. Each sample was chosen due to its temporal designation and/or because it is considered an Egyptian, Nubian, or Mediterranean area site. Additional summary data of the samples including countries/regions of origin are described below and listed in Table 5. Additional descriptions of samples are described in Appendix 2.

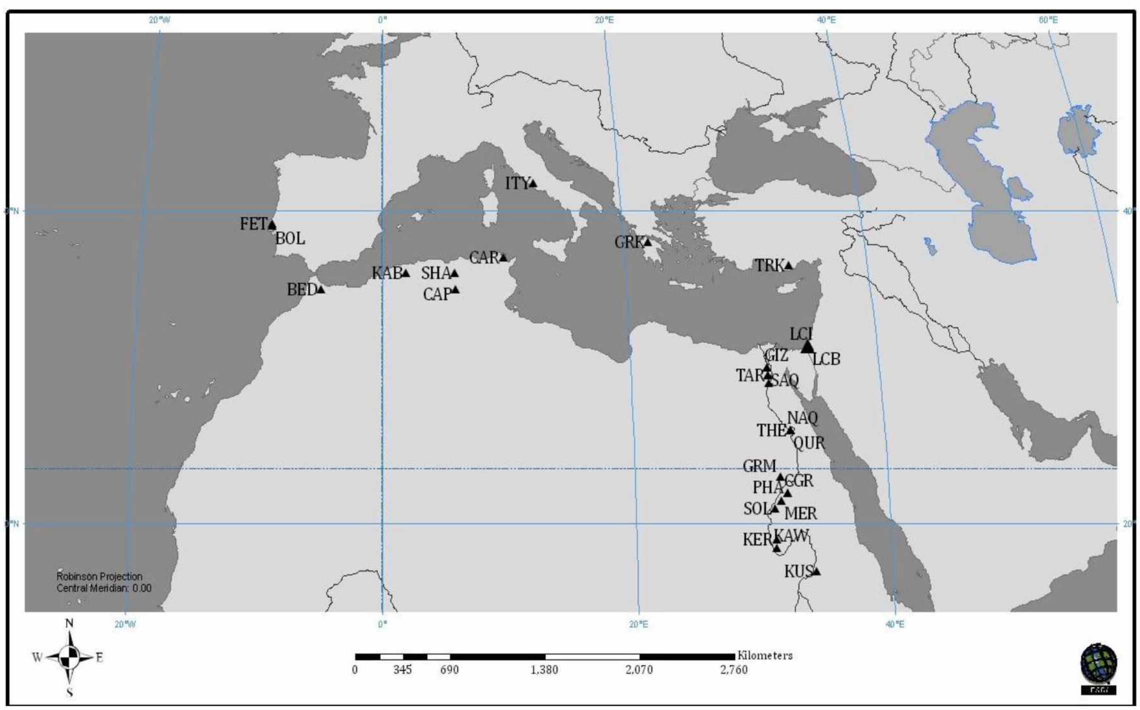


Figure 4. Map indicating location of comparative samples.

Table 5. Distribution of 26 comparative samples

Sample	Cultural Affiliation	Site(s)/region of origin	Date	No.
BED	Bedouin	Morocco, Tunisia, Libya	19-20th century A.D.	49
BOL	Bolores	Portugal	2800-1800 B.C.E.	22
CAP	Capsian	Tunisia, Algeria, Spain	6500-6000 B.C.E.	22
CAR	Carthage	Tunisia	751-146 B.C.E.	28
CGR	C-Group Nubians	Nubia	2000-1600 B.C.E.	62
FET	Feteira II	Portugal	3600-2900 B.C.E.	68
GEG	Greek Egyptian	Egypt	332-330 B.C.E.	46
GIZ	Giza	Egypt	664-332 B.C.E.	62
GRK	Greek	Greece	475-300 B.C.E. and historic	77
GRM	Gebel Ramlah	Nubia	4,650-4400 B.C.E.	59
ITY	Italy	Italy	30 B.C.E.-A.D. 395 and modern	90
KAB	Kabyle/Berber	Algeria	19th-20th century A.D.	32
KAW	Kawa	Nubia	2500-1750 B.C.E.	37
KER	Kerma	Nubia	1750-1500 B.C.E.	63
KUS	Kushite	Nubia	600 B.C.E.-A.D. 550	63
LIS	Lisht	Egypt	1985-1773 B.C.E.	61
MER	Meroitic	Nubia	100 B.C.E.-A.D. 350	94
NAQ	Naqada/Egyptian	Sudan	4000-3200 B.C.E.	65
PHA	Pharonic	Nubia	1650-1350 B.C.E.	38
QUR	Qurneh	Egypt	1295-1186 B.C.E.	67
SAQ	Saqqara	Egypt	2613-2494 B.C.E.	41
SHA	Shawia/Berber	Algeria	19th century A.D.	26
SOL	Soleb	Nubia	1550-1380 B.C.E.	32
TAR	Tarkhan	Egypt	3000-2890 B.C.E.	51
THE	Thebes	Egypt	2055-1773 B.C.E.	54
TRK	Turkey	Turkey	300 B.C.E.	40

Methods

Data Collection. The primary goal of the present study was to estimate biological affinity between the Bronze and Iron Age individuals of the Lachish collection using non-metric morphological data, and then to estimate overall biological affinity of the entire collection in the Mediterranean region. Each individual in the collection was inspected for observable dental morphological traits, root traits, oral tori and rocker jaw. Of the 776 individuals examined, 399 had at least one scorable trait. Excluding midline diastema, all traits observed comprise the Arizona State University Dental Anthropology System (ASUDAS). ASUDAS protocols are well established for determining intra-trait variation (Scott, 1973, 1980; Turner et al. 1985, 1987, 1990, 1991; Irish, 1993, 1994, 1997, 1998 a,b,c, 2000, 2005, 2006, 2008, 2010; Guatelli-Steinberg et al., 2001; Irish and Hemphill, 2001; Jackes et al., 2001; Coppa et al., 2007; Edgar, 2007; Bernal et al., 2009, 2010). Traits were scored using 24 rank-scale reference plaques and were recorded using the standard ASUDAS form.

All specimens were examined under strong lighting with a 10x hand lens when necessary. Because of the high number of skulls with no associated mandible, and the number of unassociated mandibles in both the Bronze and Iron Age samples, composite individuals were created when necessary by assigning an unassociated mandible with a randomly chosen skull of the corresponding tomb and time period. This technique limits the probability of counting an individual multiple times for a given trait, and is acceptable when analyzing population affinity opposed to individual affinity (Irish, personal communication, 2009). After recording traits for both antimeres, the one with the highest expression was counted. This method is used to avoid errors due to dental asymmetry and includes the highest expression for each individual (Turner et al., 1991). Males and females were pooled, as is standard ASUDAS protocol (Irish, 1997). Inter- and intra-observer scoring error were calculated between three observers, Joel D. Irish, Briana C. Horwath, and Clarissa R. Dicke-Toupin, using a paired samples T-test and fell in the acceptable range (Nichol and Turner, 1986). For a full description of ASUDAS, see Turner et al. (1991).

Quantitative analysis: MMD. Once recorded into a Predictive Analytics Software® (PASW®) 18.0 database, the 36 trait frequencies for each individual were dichotomized into categories of present or absent based on the standard morphological thresholds determined by Scott (1973), Nichol (1990), and Turner (1985, 1987). Dichotomization of the trait frequencies into rank-scale data is necessary for the use of multivariate applications (Irish, 2005). All traits were dichotomized according to standard ASUDAS procedure (Turner, 1985, 1987; Irish 1993) except the mandibular trait LM1 Protostylid, which was considered present at rank +3-6 as opposed to the standard rank of +1-6 to avoid intra-observer error (Irish, personal communication, 2011).

Assuming that phenetic similarity approximates genetic affinity, a distance statistic was used that provides a quantitative estimate of inter-sample biological distance based on similarities among traits (Irish, 2006). C.A.B. Smith's Mean Measure of Divergence statistic was chosen accompanied by the Freeman Tukey angular transformation (See Figure 3), which corrects for low and high trait frequencies and small sample sizes (Freeman and Tukey, 1950; Green and Suchey, 1976; Irish, 2010). This distance statistic is commonly used in affinity studies (Berry and Berry, 1967, 1972; Berry, 1974; Sjovold, 1973, 1977; Irish and Turner, 1990; Irish, 1993, 1997, 1998 a,b,c, 2005, 2006, 2008, 2010; Larsen, 1997; Irish and Guatelli-Steinberg, 2003; Bailey, 2008), and is a dissimilarity measure meaning that low values indicate greater affinity, and high values indicate phenetic distance (Irish, 2010). Irish (2010) demonstrated that MMD values are strongly correlated with geographic distances, and an appropriate statistic for affinity studies.

MMD formula with Freeman and Tukey (1950) angular transformation incorporated.

$$\mathrm{MMD} = \frac{\sum_{i=1}^{r}(\theta_{1i} - \theta_{2i})^2 - (1/(n_{1i} + {}^{1}/_{2}) + 1/(n_{2i} + {}^{1}/_{2}))}{r} \qquad (1)$$

Where:

r= Number of uncorrelated traits

θ= Angular transformation, where the observed proportion, p, is an unbiased estimator of the population proportion, P.

n= number of individuals examined for trait "i"

Isolation-by-distance. To better understand how Lachish fits into the Mediterranean region, and to gain a clearer picture of the biological landscape of the area, an isolation-by-distance model was tested. The latitudes and longitudes of each comparative site used in the study were entered and plotted on a Robinson projected coordinate system world map using WGS 1984 geographic coordinate system in ARCGIS® 9.3.1. Once the MMD distances between Lachish and the comparative samples were calculated, the values were compared to the geographic inter-sample distances using Pearson's R correlation coefficient in PASW® 18. The intent here was to evaluate the fit of Wright's (1938, 1940, 1943) and Male'cot's (1969) isolation-by-distance model using the phenetic and geographic distances. The isolation-by-distance model posits that phenetic (genetic) affinity between populations decreases exponentially as corresponding geographic distance increases. The model is driven by the assumption that geographic distance has a restrictive factor on gene flow rates (Relethford, 2004). As detailed in Kimura and Weiss (1964) and Konigsberg (1990), the uni-dimensional stepping stone variant of the isolation-by-distance model was tested by assessing the level of correlation between distances (Irish, 2010). Assuming an infinite number of subpopulations existing along a linear habitat that exchange migrants with two contiguous subpopulations at an equivalent rate, this variant predicts a decreasing gene frequency correlation accompanying increasing geographic distances (Kimura and Weiss, 1964; Konigsberg, 1990; Schillaci et al., 2009; Irish, 2010). Because the current research was designed to address biological continuity vs. discontinuity, not migration patterns, the stepping-stone variant of the isolation-by-distance model was used as the simplest method of exploring the relationship between genes and geography. Researchers interested in a more in-depth study into the processes of migration and gene flow may consider using Wright's (1943) Island Model or any number of alternative models. To illustrate the relationship between phenetic distance and geographic distance, heuristic figures including scatterplots and star diagrams are utilized (Turner,1993; Guatelli-Steinberg et al., 2001; Irish, personal communication, 2011).

CHAPTER 6- RESULTS

Trait Frequencies

The 36 traits for the 28 samples (Lachish-Bronze and Iron samples, and 26 comparative samples) are listed in Table 7 and 7a (Table was split to accommodate the large amount of data; 14 samples are in Table 7, and 14 are in Table 7a). The percentage of individuals in each sample exhibiting the trait and the total number on individuals scored are listed in the table. Additionally, ASUDAS presence/absence dichotomies are listed under each trait name. Several traits are characterized by small sample sizes, particularly those of the anterior teeth and some mandibular teeth, mostly due to post-mortem loss in the samples. As such, interpretations of population specific trait frequencies must be conservative.

Before running the MMD, inter-trait correlations were calculated using Kendall's Tau b correlation coefficient. Four highly correlated traits (correlation of .6 or above) were excluded (labial curvature, LM1 deflecting wrinkle, LM1 C1-C2 crest, and LM1 protostylid; see Table 6). Highly correlated traits were dropped from the analysis because differential weighting of underlying dimensions can yield deceptive MMD results (Sjovold, 1977; Irish, 2000). The remaining 32 traits used in the MMD analysis are listed in Table 6.

Table 6. 32 traits used in study- 28 dental traits and four oral tori and rocker jaw traits used in MMD.

Trait	Presence/Absence threshold
1. Winging UI1	(+=ASU 1)
2. Palatine Torus	(+=ASU 2-3)
3. Shoveling UI1	(+=ASU 2-6)
4. Double Shoveling UI1	(+=ASU 2-6)
5. Interruption Groove UI2	(+=ASU +)
6. Tuberculum Dentale UI2	(+=ASU 2-6)
7. Bushman Canine UC	(+=ASU 1-3)
8. Distal Acc. Ridge UC	(+=ASU 2-5)
9. Hypocone UM2	(+=ASU 3-5)
10. Cusp 5 UM1	(+=ASU 2-5)
11. Carabelli's Trait UM1	(+=ASU 2-7)
12. Parastyle UM3	(+=ASU 1-5)
13. Enamel Extension UM1	(+=ASU 1-3)
14. Root Number UP1	(+=ASU 2+)
15. Root Number UM2	(+=ASU 3+)
16. Peg-Reduced UI2	(+=ASU P or R)
17. Odontome P1-P2	(+=ASU +)
18. Congenital Absence UM3	(+=ASU -)
19. Midline Diastema UI1	(+ 0.5 mm)
20. Lingual Cusp LP2	(+=ASU 2-9)
21. Anterior Fovea LM1	(+=ASU 2-4)
22. Mandibular Torus	(+=ASU 2-3)
23. Groove Pattern LM2	(+=ASU Y)
24. Rocker Jaw	(+=ASU 1-2)
25. Cusp Number LM1	(+=ASU 6+)
26. Cusp Number LM2	(+=ASU 5+)
27. Cusp 7 LM1	(+=ASU 2-4)
28. Tome's Root LP1	(+=ASU 3-5)
29. Root Number LC	(+=ASU 2+)
30. Root Number LM1	(+=ASU 3+)
31. Root Number LM2	(+=ASU 2+)
32. Torsomolar Angle LM3	(+=ASU +)

Table 7. Trait percent frequencies for 14 of 28 samples.

Trait		LCB	LCI	BED	BOL	CAP	CAR	CGR	FET	GEG	GIZ	GRK	GRM	ITY	KAB
Winging UI1	**%**	0.0	0.0	5.4	0.0	0.0	10.0	16.3	0.0	0.0	4.3	1.5	0.0	3.9	0.0
(+=ASU 1)	**n**	7	21	37	0	5	20	49	0	41	47	68	32	76	29
Labial Curvature UI1	**%**	14.3	0.0	8.3	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	6.5	0.0	12.5
(+=ASU 2-4)	**n**	7	15	24	11	4	14	19	31	16	17	5	31	29	8
Palatine Torus	**%**	0.0	0.0	2.4	0.0	0.0	5.9	0.0	0.0	0.0	0.0	4.3	0.0	10.4	3.4
(+=ASU 2-3)	**n**	32	355	41	0	10	17	42	0	43	47	70	28	77	29
Shoveling UI1	**%**	0.0	6.3	8.0	0.0	0.0	22.2	10.5	5.1	5.9	15.4	0.0	42.9	26.9	14.3
(+=ASU 2-6)	**n**	7	16	25	10	5	9	19	39	17	13	5	28	26	7
Double Shoveling UI1	**%**	0.0	0.0	12.5	0.0	0.0	15.4	0.0	0.0	0.0	0.0	0.0	6.1	0.0	12.5
(+=ASU 2-6)	**n**	7	16	24	11	5	13	17	43	15	16	5	33	27	8
Interruption Groove UI2	**%**	0.0	3.1	37.5	61.5	60.0	33.3	45.0	16.7	22.2	4.2	35.0	18.5	13.3	21.4
(+=ASU +)	**n**	7	32	24	13	5	12	20	42	27	24	20	27	30	14
Tuberculum Dentale UI2	**%**	30.0	29.4	43.5	46.2	60.0	27.3	35.0	22.0	45.8	25.0	5.3	59.3	36.7	50.0
(+=ASU 2-6)	**n**	10	34	23	13	5	11	20	41	24	24	19	27	30	12
Bushman Canine UC	**%**	0.0	0.0	0.0	0.0	22.2	0.0	0.0	0.0	0.0	6.3	8.7	10.7	2.6	0.0
(+=ASU 1-3)	**n**	14	77	29	16	9	15	26	41	30	32	23	28	39	16
Distal Acc. Ridge UC	**%**	0.0	8.3	12.0	54.5	42.9	0.0	12.5	84.6	0.0	7.1	8.3	31.8	19.2	27.3
(+=ASU 2-5)	**n**	4	36	25	11	7	8	16	39	24	28	12	22	26	11
Hypocone UM2	**%**	85.7	77.0	58.8	77.8	100.0	68.4	76.1	73.7	79.3	84.2	50.0	91.9	59.7	63.6
(+=ASU 3-5)	**n**	21	217	34	9	10	19	46	38	29	38	54	37	72	22
Cusp 5 UM1	**%**	24.0	29.5	8.8	44.4	30.0	8.3	40.0	31.4	0.0	5.7	5.7	10.5	17.5	11.8
(+=ASU 2-5)	**n**	25	251	34	9	10	12	25	35	24	35	53	19	63	17
Carabelli's Trait UM1	**%**	89.5	71.3	54.5	45.5	100.0	37.5	75.0	59.5	82.6	72.7	85.4	88.0	61.3	57.9
(+=ASU 2-7)	**n**	19	164	33	11	6	16	24	37	23	33	48	25	62	19
Parastyle UM3	**%**	0.0	1.6	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(+=ASU 1-5)	**n**	9	128	20	9	9	14	40	36	28	26	33	32	41	22
Enamel Extension UM1	**%**	0.0	5.5	5.6	10.0	0.0	5.6	2.3	8.6	13.8	6.4	16.7	9.4	5.8	0.0
(+=ASU 1-3)	**n**	8	255	36	10	13	18	43	35	29	47	54	32	69	23
Root Number UP1	**%**	54.5	56.8	50.0	12.5	33.3	52.4	83.0	33.3	64.3	62.5	61.9	72.2	59.3	52.2
(+=ASU 2+)	**n**	11	199	32	8	12	21	47	30	28	32	63	36	59	23
Root Number UM2	**%**	100.0	85.9	69.0	75.0	85.7	77.8	86.7	84.4	21.4	72.7	58.3	60.6	76.9	68.4
(+=ASU 3+)	**n**	5	64	29	4	7	18	30	32	14	22	36	33	39	19

Table 7. Continued

Peg-Reduced UI2	**%**	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	5.3	9.6	6.3
(+=ASU P or R)	**n**	10	61	27	13	10	13	56	44	43	57	73	38	83	16
Odontome P1-P2	**%**	0.0	0.5	0.0	11.1	0.0	0.0	5.3	10.0	0.0	0.0	0.0	0.0	2.7	0.0
(+=ASU +)	**n**	21	218	40	18	12	16	38	40	30	42	44	27	74	22
Congenital Absence UM3	**%**	15.0	16.1	21.1	0.0	16.7	30.4	7.1	0.0	18.2	15.4	17.6	15.0	23.5	3.4
(+=ASU -)	**n**	20	310	38	8	12	23	56	42	44	52	68	40	81	29
Midline Diastema UI1	**%**	0.0	4.8	8.8	0.0	0.0	5.3	0.0	0.0	0.0	0.0	3.0	12.1	4.9	12.0
(+ 0.5 mm)	**n**	2	21	34	0	5	19	52	0	43	52	66	33	82	25
Lingual Cusp LP2	**%**	100.0	71.4	64.3	66.7	84.6	36.4	72.4	69.2	65.5	61.9	60.0	61.9	34.9	69.2
(+=ASU 2-9)	**n**	3	28	28	3	13	11	29	26	29	21	10	21	43	13
Anterior Fovea LM1	**%**	100.0	20.8	37.5	37.5	45.5	20.0	100.0	33.3	35.3	17.4	36.4	35.7	51.4	60.0
(+=ASU 2-4)	**n**	1	24	24	8	11	10	16	24	17	23	11	14	35	10
Mandibular Torus	**%**	0.0	3.8	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0
(+=ASU 2-3)	**n**	8	78	35	0	19	13	50	0	40	51	34	41	73	19
Groove Pattern LM2	**%**	40.0	34.0	46.9	9.1	41.2	38.5	50.0	0.0	17.6	29.5	43.5	66.7	26.2	27.8
(+=ASU Y)	**n**	5	50	32	11	17	13	46	39	34	44	23	36	61	18
Rocker Jaw	**%**	0.0	0.0	9.4	0.0	17.6	7.7	27.3	0.0	12.5	13.7	30.3	20.5	12.5	10.5
(+=ASU 1-2)	**n**	7	81	32	0	17	13	44	0	40	51	33	39	72	19
Cusp Number LM1	**%**	0.0	3.9	12.5	8.3	17.6	0.0	5.7	14.3	3.8	2.3	0.0	7.7	2.0	31.3
(+=ASU 6+)	**n**	2	51	32	12	17	11	35	35	26	43	19	26	51	16
Cusp Number LM2	**%**	37.5	37.7	42.9	18.2	38.9	16.7	56.3	48.6	6.9	25.0	47.6	78.1	35.6	33.3
(+=ASU 5+)	**n**	8	69	28	11	18	12	32	35	29	36	21	32	45	18
Deflecting Wrinkle LM1	**%**	0.0	0.0	15.6	12.5	20.0	10.0	36.4	4.5	4.0	5.7	17.6	31.3	12.5	6.7
(+=ASU 2-3)	**n**	2	14	32	8	10	10	22	22	25	35	17	16	48	15
C1-C2 Crest LM1	**%**	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	5.3	2.9	5.9	0.0	6.4	0.0
(+=ASU +)	**n**	2	18	33	8	9	9	26	21	19	34	17	21	47	14
Protostylid LM1	**%**	0.0	1.5	0.0	0.0	0.0	0.0	6.5	0.0	0.0	0.0	0.0	4.0	0.0	0.0
(+=ASU 1-6)	**n**	5	67	33	10	15	10	31	27	25	35	19	25	51	16
Cusp 7 LM1	**%**	0.0	6.1	5.9	10.0	16.7	7.7	11.6	0.0	6.7	4.3	5.6	5.9	5.4	5.9
(+=ASU 2-4)	**n**	2	33	34	10	18	13	43	33	30	47	18	34	56	17
Tome's Root LP1	**%**	0.0	3.0	6.3	0.0	0.0	11.1	19.6	3.6	14.3	0.0	7.1	9.5	10.5	5.3
(+=ASU 3-5)	**n**	2	33	32	9	15	9	46	28	28	47	28	42	57	19

Table 7. Continued

Root Number LC	**%**	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0	0.0	1.9	3.4	4.9	3.3	20.0
(+=ASU 2+)	**n**	9	69	26	8	12	3	49	32	26	52	29	41	60	10
Root Number LM1	**%**	0.0	0.0	0.0	0.0	5.9	0.0	2.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0
(+=ASU 3+)	**n**	2	6	33	7	17	11	39	30	23	34	22	43	43	17
Root Number LM2	**%**	100.0	100.0	88.9	100.0	85.7	80.0	91.2	93.1	50.0	82.4	91.3	80.5	100.0	88.9
(+=ASU 2+)	**n**	1	5	27	9	14	10	34	29	12	34	23	41	57	18
Torsomolar Angle LM3	**%**	0.0	14.3	20.0	0.0	23.1	10.0	4.8	0.0	21.9	2.9	13.0	6.8	16.3	21.4
(+=ASU +)	**n**	6	49	25	0	13	10	42	0	32	35	23	44	43	14

Table 7a. Trait percent frequencies for last 14 of 28 samples.

Trait		**KAW**	**KER**	**KUS**	**LIS**	**MER**	**NAQ**	**PHA**	**QUR**	**SAQ**	**SHA**	**SOL**	**TAR**	**THE**	**TRK**
Winging UI1	**%**	8.0	5.4	4.2	2.1	12.8	6.0	3.3	5.2	2.8	0.0	8.3	6.8	5.6	0.0
(+=ASU 1)	**n**	25	56	48	47	39	50	30	58	36	26	24	44	54	36
Labial Curvature UI1	**%**	0.0	7.7	0.0	0.0	4.9	0.0	0.0	4.8	0.0	14.3	12.5	6.7	4.8	0.0
(+=ASU 2-4)	**n**	24	13	32	11	41	8	5	21	11	7	8	30	21	10
Palatine Torus	**%**	5.0	1.8	3.1	0.0	10.7	0.0	0.0	0.0	0.0	0.0	10.3	0.0	0.0	0.0
(+=ASU 2-3)	**n**	20	55	32	51	84	50	29	61	39	25	29	44	51	35
Shoveling UI1	**%**	33.3	22.2	26.9	0.0	38.9	14.3	25.0	0.0	0.0	0.0	11.1	7.1	15.8	0.0
(+=ASU 2-6)	**n**	21	9	26	10	36	7	4	17	7	7	9	28	19	10
Double Shoveling UI1	**%**	0.0	0.0	3.7	0.0	4.5	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0
(+=ASU 2-6)	**n**	23	7	27	12	44	7	3	22	8	8	8	26	18	10
Interruption Groove UI2	**%**	20.0	9.1	26.1	31.6	36.2	9.1	20.0	3.7	33.3	46.2	30.8	8.8	20.8	15.4
(+=ASU +)	**n**	20	11	23	19	47	11	5	27	9	13	13	34	24	13
Tuberculum Dentale UI2	**%**	70.0	8.3	50.0	36.8	40.5	27.3	20.0	52.2	66.7	25.0	25.0	28.1	30.0	15.4
(+=ASU 2-6)	**n**	20	12	22	19	42	11	5	23	6	12	12	32	20	13
Bushman Canine UC	**%**	0.0	16.7	10.0	0.0	19.6	0.0	0.0	0.0	0.0	0.0	0.0	5.4	3.0	0.0
(+=ASU 1-3)	**n**	24	18	20	27	51	22	8	31	10	14	11	37	33	19
Distal Acc. Ridge UC	**%**	16.7	18.2	42.9	0.0	31.0	15.0	50.0	8.7	0.0	22.2	0.0	3.8	10.5	6.3
(+=ASU 2-5)	**n**	18	11	14	23	42	20	4	23	6	9	7	26	19	16

Table 7a. Continued

Hypocone UM2	**%**	84.6	91.7	87.9	88.1	78.5	90.9	83.3	87.0	95.7	68.4	78.9	75.0	85.7	60.0
(+=ASU 3-5)	**n**	26	48	33	42	79	44	24	46	23	19	19	40	42	25
Cusp 5 UM1	**%**	25.0	24.1	28.6	15.4	10.9	17.5	16.7	5.3	0.0	10.0	14.3	0.0	14.3	4.5
(+=ASU 2-5)	**n**	12	29	14	26	64	40	12	38	9	20	7	23	28	22
Carabelli's Trait UM1	**%**	90.0	51.6	55.0	60.9	58.6	68.4	78.6	70.6	100.0	55.6	12.5	67.9	90.3	85.7
(+=ASU 2-7)	**n**	10	31	20	23	58	38	14	34	16	18	8	28	31	21
Parastyle UM3	**%**	8.0	5.4	0.0	0.0	0.0	0.0	4.3	3.0	0.0	7.7	0.0	2.6	0.0	0.0
(+=ASU 1-5)	**n**	25	37	29	32	58	28	23	33	15	13	15	38	37	13
Enamel Extension UM1	**%**	0.0	4.0	12.5	14.9	13.5	15.2	0.0	9.8	0.0	4.8	10.0	0.0	4.8	25.0
(+=ASU 1-3)	**n**	17	50	32	47	89	46	27	51	18	21	20	45	42	24
Root Number UP1	**%**	68.0	80.4	57.1	61.9	53.8	76.1	72.0	70.6	89.7	52.2	69.2	75.0	85.3	69.0
(+=ASU 2+)	**n**	25	51	49	42	78	46	25	34	29	23	13	32	34	29
Root Number UM2	**%**	80.0	90.2	61.5	77.3	81.7	73.5	84.2	70.0	82.6	72.2	90.9	72.2	81.3	62.1
(+=ASU 3+)	**n**	25	41	39	44	60	34	19	30	23	18	11	18	32	29
Peg-Reduced UI2	**%**	0.0	1.6	0.0	0.0	1.9	0.0	11.1	1.6	6.1	0.0	0.0	4.0	0.0	5.7
(+=ASU P or R)	**n**	31	63	54	22	54	60	36	62	33	13	24	50	54	35
Odontome P1-P2	**%**	5.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0
(+=ASU +)	**n**	20	41	38	42	82	49	21	50	12	23	12	43	39	30
Congenital Absence UM3	**%**	0.0	16.7	9.6	3.6	7.3	3.7	3.0	18.6	20.0	23.1	11.5	4.1	19.6	21.9
(+=ASU -)	**n**	29	60	52	55	82	54	33	59	35	26	26	49	51	32
Midline Diastema UI1	**%**	0.0	3.3	8.5	7.7	8.7	0.0	3.0	0.0	0.0	0.0	0.0	4.2	1.9	0.0
(+ 0.5 mm)	**n**	28	60	47	39	23	52	33	61	33	23	25	48	53	37
Lingual Cusp LP2	**%**	60.0	86.4	75.0	66.7	86.0	95.7	75.0	54.3	66.7	92.3	44.4	77.8	70.3	82.4
(+=ASU 2-9)	**n**	15	22	28	12	50	23	8	35	12	13	9	18	37	17
Anterior Fovea LM1	**%**	33.3	43.8	58.3	37.5	40.0	18.8	0.0	35.3	14.3	29.4	40.0	0.0	42.9	40.0
(+=ASU 2-4)	**n**	6	16	12	8	35	16	2	17	7	17	5	2	14	10
Mandibular Torus	**%**	3.0	0.0	0.0	0.0	1.2	1.7	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0
(+=ASU 2-3)	**n**	33	60	52	37	81	58	24	52	37	24	31	49	52	30

Table 7a. Continued

Groove Pattern LM2	**%**	50.0	41.3	45.5	37.5	10.5	45.8	25.0	20.0	22.7	36.8	52.9	30.6	25.0	5.9
(+=ASU Y)	**n**	24	46	44	24	76	48	16	50	22	19	17	36	48	17
Rocker Jaw	**%**	3.1	5.3	18.2	32.4	22.0	24.1	11.1	9.6	24.3	8.3	10.7	16.3	22.6	13.8
(+=ASU 1-2)	**n**	32	57	44	37	82	54	18	52	37	24	28	43	53	29
Cusp Number LM1	**%**	7.7	0.0	5.7	5.6	6.9	7.9	0.0	6.9	0.0	9.5	0.0	5.0	2.8	0.0
(+=ASU 6+)	**n**	13	28	35	18	72	38	9	29	10	21	8	20	36	19
Cusp Number LM2	**%**	41.7	41.2	51.6	20.8	33.3	27.8	25.0	22.5	25.0	31.6	26.7	50.0	26.3	41.2
(+=ASU 5+)	**n**	12	34	31	24	75	36	16	40	12	19	15	28	38	17
Deflecting Wrinkle LM1	**%**	18.2	11.1	20.7	22.2	7.0	15.2	50.0	29.2	0.0	5.0	0.0	12.5	13.3	6.7
(+=ASU 2-3)	**n**	11	27	29	9	57	33	6	24	8	20	4	16	30	15
C1-C2 Crest LM1	**%**	0.0	0.0	3.6	11.1	4.9	3.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0
(+=ASU +)	**n**	11	27	28	9	61	33	8	24	5	20	4	16	26	13
Protostylid LM1	**%**	0.0	0.0	3.1	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(+=ASU 1-6)	**n**	13	26	32	15	69	36	7	32	14	21	7	20	41	17
Cusp 7 LM1	**%**	4.8	17.1	14.3	0.0	3.5	10.9	0.0	5.6	0.0	4.8	0.0	3.7	6.8	0.0
(+=ASU 2-4)	**n**	21	35	42	23	85	46	12	36	20	21	17	27	44	19
Tome's Root LP1		28.6	25.0	13.5	8.6	6.0	10.7	8.7	12.9	6.7	10.5	10.5	13.6	11.1	0.0
(+=ASU 3-5)	**n**	28	52	52	35	50	56	23	31	30	19	19	44	36	25
Root Number LC		0.0	1.9	1.8	5.6	1.5	5.1	4.2	0.0	6.1	0.0	5.6	4.4	0.0	0.0
(+=ASU 2+)	**n**	31	52	55	36	65	59	24	27	33	16	18	45	35	22
Root Number LM1		0.0	2.0	2.1	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3
(+=ASU 3+)	**n**	25	49	48	29	45	39	15	29	26	22	16	33	39	19
Root Number LM2		75.0	94.0	88.9	86.2	89.6	86.1	91.7	85.7	86.7	95.5	80.0	85.0	91.7	89.5
(+=ASU 2+)	**n**	24	50	45	29	48	36	12	28	30	22	20	40	36	19
Torsomolar Angle LM3		10.3	15.7	4.3	30.8	16.7	2.2	0.0	2.7	0.0	23.5	5.3	5.6	22.5	16.7
(+=ASU +)	**n**	29	51	46	26	60	46	20	37	23	17	19	36	40	30

MMD

Compared to the other samples, the Lachish Bronze Age (LCB) sample had relatively low percentages of shoveling UI1, interruption groove UI2, distal accessory ridge UC, and rocker jaw, with relatively high percentages of labial curvature UI1, and Carabelli's cusp UM1. The Lachish Iron Age (LCI) displayed relatively low percentages of shoveling UI1, interruption grove UI2, distal accessory ridge UC, and rocker jaw, with relatively high percentages of cusp 5 UM1, and Protostylid LM1.

Lachish Bronze Age sample (LCB). The MMD distances for LCB and LCI are presented in Table 8. Due to the small sample size and relatively high amount of missing data in the sample, the MMD analysis indicates that LCB is pheneticlly similar to all the comparative samples, including LCI. The MMD results must be interpreted carefully as, because of the small sample size, there are too few distinguishing morphological characteristics to be truly representative of the population as a whole. With this caveat in mind, the LCB sample is not significantly different at the 0.25 level from LCI or any other of the comparative sample populations.

Lachish Iron Age sample (LCI). The MMD analysis indicates that LCI is not significantly different from LCB (see sample size discussion above) with an MMD score of 0.00. The MMD distances between LCI and the comparative samples can be grouped into four levels of affinity scaled from most to least like the Iron Age individuals of Lachish: most similar to LCI, second most similar to LCI, third most similar to LCI, and least similar to LCI. All trait frequencies are listed in Table 6. If the observed dental patterns are indicative of underlying genetic variation (per Scott et al., 1983; Rightmire, 1999), LCI is most phenetically similar to three Egyptian samples (GIZ, LIS, NAQ), one Phoenician sample from Carthage (CAR), and one Nubian sample (PHA), with a total mean MMD of .019. The samples that are second most like LCI are three Egyptian (TAR, THE, and QUR), three Northwest African, including two Berber groups (BED, KAB, and SHA), one Nubian (SOL), and three European groups (GRK, ITY, and TRK), with a mean MMD score of .053. The groups that are third most similar to LCI include five Nubian samples (GRM, KAW, KER, KUS, and MER), one North African (CAP), one Egyptian (SAQ), and one European sample (BOL), with a mean MMD score of .099. The samples least like LCI are one European (FET), one Nubian (CGR), and one Greek/Egyptian group (GEG), with a mean MMD score of .170. The low MMD scores of especially the first, and then second groups indicate a closer affinity between Lachish and Egyptian groups primarily, and secondarily with other Mediterranean groups within the samples.

Isolation-by-distance. The Pearson's R Coefficient Correlation was used to test whether the pattern of affinity between LCI/LCB and the comparative samples fit the stepping-stone isolation-by-distance model. The MMD distances between Lachish and the comparative samples were calculated, and the values were compared to the Euclidean inter-sample distance matrix. The Pearson's R value is

.223 indicating a slight positive relationship between phenetic distance and geographic distance, however the overall significance level is .273, indicating that the results are not statistically significant (Table 9). As such, the pattern of affinity between LCI/LCB and the comparative samples do not fit an isolation-by-distance model. The scatter-plots in Figure 5 demonstrate the results of the correlation coefficient, which illustrate that neither LCB nor LCI exhibit significant phenetic/geographic correlations.

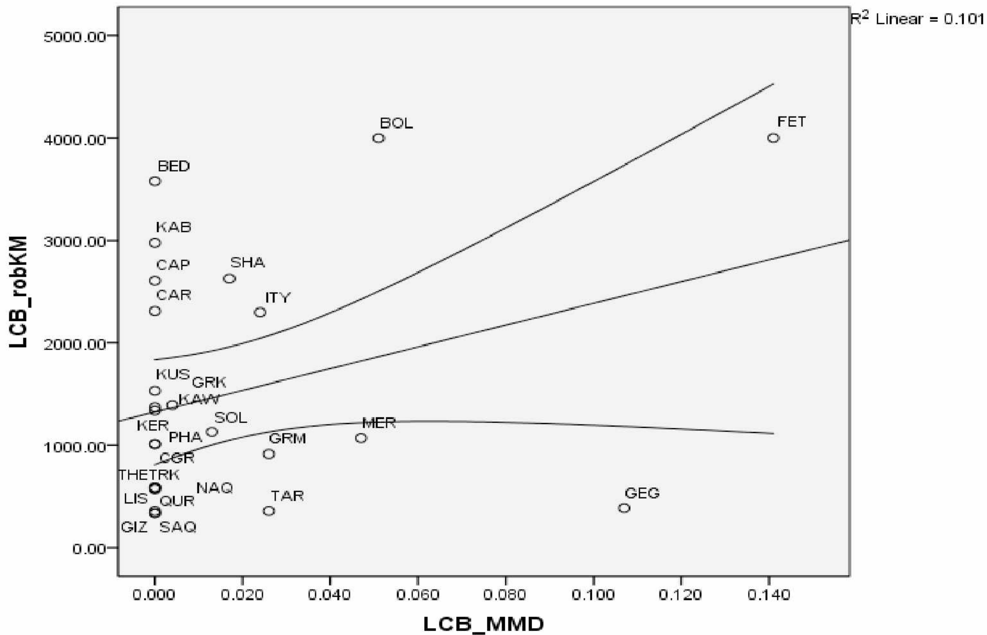
Table 8. MMD values for 32 traits between LCB and LCI and 26 comparative samples[1]

Sample and associated date	LCB	LCI
Lachish Bronze (1150-1200/1098 B.C.E.)	0.000	0.000
Lachish Iron (1098/1200-1047 B.C.E.)	0.000	0.000
Bedouin (19th-20th century A.D.)	0.000	**0.043**
Bolores (2800-1800 B.C.E.)	0.051	**0.107**
Capsian (6500-6000 B.C.E.)	0.000	**0.103**
Carthage (751-146 B.C.E.)	0.000	0.025
C- Group Nubians (2000-1600 B.C.E.)	0.000	**0.176**
Feteira II (3600-2900 B.C.E.)	0.141	**0.163**
Greek-Egyptian (474-300 B.C.E.)	0.107	**0.168**
Giza (664-332 B.C.E.)	0.000	0.025
Greek (475-300 B.C.E. and historic)	0.000	0.040
Gebel Ramlah (4,650-4400 B.C.E.)	0.026	**0.113**
Italy (30 B.C.E. - A.D. 395 and modern)	0.024	**0.056**
Kabyle (19th- 20th century A.D.)	0.000	**0.059**
Kawa (2500-1750 B.C.E.)	0.005	**0.093**
Kerma (1750-1500 B.C.E.)	0.000	**0.092**
Kushite (600 B.C.E. -A.D. 550)	0.000	**0.082**
Lisht (1985-1773 B.C.E.)	0.000	0.017
Meroitic (100 B.C.E. -A.D. 350)	0.047	**0.113**
Naqada (4000-3200 B.C.E.)	0.000	0.029
Pharonic (1650-1350 B.C.E.)	0.000	0.000
Qurneh (1295-1186 B.C.E.)	0.000	**0.042**
Saqqara (2613-2494 B.C.E.)	0.000	**0.088**
Shawia (19th century A.D.)	0.017	**0.079**
Soleb (1550-1380 B.C.E.)	0.013	**0.070**
Tarkhan (3000-2890 B.C.E.)	0.026	0.049
Thebes (2055-1773 B.C.E.)	0.000	**0.050**
Turkey (300 B.C.E.)	0.000	0.039

[1] See Table 5 for sample details. Bolded values indicate significant difference at .025 level.

Table 9. Pearson's R Correlation Coefficient value and significance.

Test	Value	Approx. Sig.
Pearson's R	.223	.273[c]



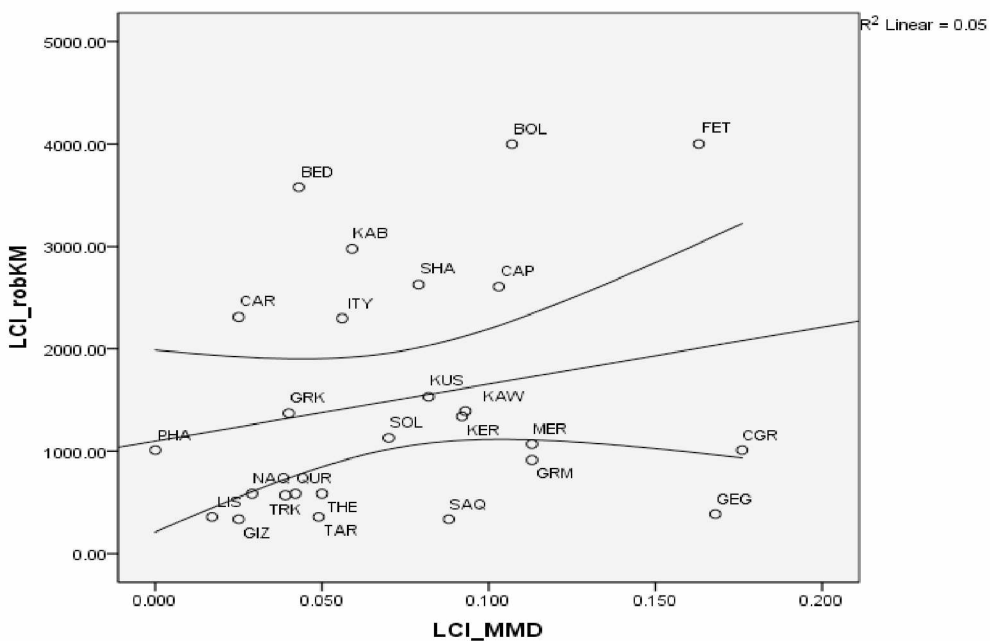


Figure 5. Scatter-plots showing relationship between geography and MMD values. LCB is represented on the upper plot, LCI, the lower plot. Lines on plot indicate the 95% confidence interval.

CHAPTER 7- DISCUSSION

Are material culture changes observed between the Late Bronze and Early Iron Age inhabitants of Lachish the result of immigrants settling the region, or an in situ evolution of practices by the same indigenous peoples?

The research presented here suggests that the Late Bronze Age and Early Iron Age inhabitants of Lachish are biologically continuous. The MMD score between LCB and LCI is 0.00, implying no observable phenetic distance between the samples. Given the small sample size and missing data of the LCB sample, the results of the MMD are considered with caution. There is, however, little biological evidence to suggest a significant difference between the populations.

At the end of the Bronze Age in Lachish, the Canaanites seem to have exclusively occupied the city (Mazar, 1992; Ussishkin, 2004). A destruction layer marks the end of the period, followed by a desertion of the city as evidenced by a lack of artifacts, and rebuilding immediately following the ash layer (Ussishkin, 2004). The Early Iron Age at Lachish is associated with stratigraphic layers V-IV. The appearance of a new red-slipped, irregularly burnished pottery type becomes evident in Level V at Lachish. The rise of the Judean kingdom during the Iron Age in Palestine initiates the settlement of Lachish, and the entire Shephelah, by a new cultural group: the Judean Hebrews (Dagan, 2004; Ussishkin, 2004; Zimhoni, 2004). There is no question that cultural change occurred at Lachish; cultural change became associated with a homogenous cultural and biological group known as the

Judean Hebrews (Tufnell, 1958; Mazar, 1992; Thomas et al., 1998; Jobling, 2004; Ussishkin, 2004). As such, investigating the question of biological continuity between the individuals of the Late Bronze and Early Iron Ages at Lachish is meant to contribute evidence to determine whether the Judeans immigrated to the city and replaced the inhabitants, or whether the inhabitants adopted the cultural and religious practices of the Judean Hebrews. This leads to the hypothesis addressed in this study:

1. *Null hypothesis*- There is no difference between the Iron Age populace of the ancient city of Lachish and their Bronze Age predecessors, therefore representing biological population continuity.
2. *Alternative hypothesis*- There is a difference between the Iron Age populace of the ancient city of Lachish and their Bronze Age predecessors, therefore representing a population replacement or significant positive gene flow.

The null hypothesis can not be rejected, the Iron Age populace of the ancient city of Lachish appears to be biologically continuous with their Bronze Age predecessors, therefore representing biological population continuity and likely an evolution or adoption of differing cultural practices. If the samples used in the study were representative of their broader populations, the close affinity between the

Lachish Iron Age individuals and the Egyptian, Nubian, and Phoenician samples suggest that gene flow from the latter groups over the centuries of alternating occupations have produced a fairly biologically heterogeneous population. This conclusion is not meant to assert that Hebrew groups did not immigrate to Lachish; rather, gene flow from this cultural/ethnic group was not significant enough to suggest replacement or total biological assimilation in the Early Iron Age individuals examined here.

To further investigate heterogeneity among the Lachish sample, a simple post hoc comparison of MMD values was undertaken between the individuals of Tomb 120 and the rest of the individuals from the remaining tombs in the Iron Age sample (Judd et al., 2006). As detailed above, Tomb 120 contained approximately 1500 crania, an extraordinarily large number compared to the number of individuals in the remaining tombs. The deposition of crania and the large number of individuals differed from the conditions in the other Iron Age tombs. Of the 1500 crania, approximately 260 crania were sampled and shipped to London. One possible explanation for the heterogeneity of the Lachish sample is that the individuals of Tomb 120 represent a different cultural and/or biological group.

The MMD score of 0.00 between Tomb 120 and the remaining Iron Age tombs at Lachish indicate that the individuals in all tombs are biologically continuous. The result indicates that the heterogeneity of the Lachish sample is likely due to positive gene flow across the Bronze and Iron Ages, as well as among all observed individuals. As indicated by the low MMD score, the greatest source of gene flow likely came from Egyptian and Phoenician samples over the centuries of alternating occupations.

Egypt and Lachish

Iron Age Lachish shared the closest affinity with the Egyptian comparative samples from the sites of Lisht (LIS), Giza (GIZ), and Naqada (NAQ). Considering that Egypt's upper and ruling class occupied Lachish for many generations, the close affinity between these groups is not surprising (Mazar, 1992; Ussishkin, 2004). The Iron Age individuals demonstrate an Egyptian presence in both the group most similar to LCI, and also in the group second most similar to LCI (according to MMD values), suggesting significant continuity from at least the period of Egyptian hegemony up to the Iron Age.

Lisht (LIS) (MMD value of 0.017) is a Lower Egyptian site comprised of upper-class individuals from Ititawy, and exhibit close affinities to Upper Egyptian samples (Irish, 2006). Ititawy was the Egyptian capitol and location of the ruling class during the 12th Dynasty, or Middle Bronze in Palestine, and may have experienced high levels of in-migration, or positive gene flow, which may have produced slight levels of heterogeneity within the sample (Irish, 2006). It is assumed that besides the servants of dignitaries, upper- and ruling class individuals were the most likely of Egyptian citizens to be stationed abroad, which may further explain the affinity between the upper class individuals of the LIS sample and

Lachish (Johnson and Lovell, 1994; Prowse and Lovell, 1996; Irish, 2006). Given the low MMD value of 0.017, Lachish shares the closest affinity of any other Egyptian comparative group with the sample from Lisht.

The affinity between Giza, of Lower Egypt (MMD value of 0.025) and Lachish has no immediate explanation, and may reflect migrations of people from Lower Egypt into the Levant during the periods of Egyptian hegemony in Palestine. Beyond their Late Dynastic affiliation, little is known about the individuals comprising the GIZ sample (Irish, 2006). The relative close geographic distance between Giza and Lachish might account for gene flow between the sites.

Naqada is an Upper Egyptian site; it is the only Upper Egyptian site represented in the group most similar to Lachish, and as such, the affinity between the two samples is somewhat unexpected (MMD value of 0.029). Naqada is a predynastic city that, with the exception of three specimens, is affiliated with lower class Egyptians. While no predynastic occupation in Lachish has been documented, the possibility of contact between predynastic Egyptians and Palestinians remains fairly high. Trade and commerce between the regions were documented as early as the Chalcolithic in Lachish (Tufnell, 1950). Whether significant gene flow accompanied these early interactions is not known. Using non-metric dental analysis, Irish (2006) documented marked diachronic homogeneity among the majority of Egyptian samples he studied (which included Naqada in the analysis), meaning that many Egyptian samples, regardless of time period, are not significantly different. Therefore, affinity between Lachish and Naqada may be independent of temporal influence, and instead reflect affinity with lower class Egyptians in general. As previously mentioned, it is assumed that mostly upper and ruling class individuals were stationed abroad. It is possible, however, that the affinity between Naqada and Lachish reflects the working class individuals who accompanied and/or catered to the ruling Egyptian officials abroad, therefore, possibly suggesting a significant Egyptian lower class population at Lachish.

Phoenicia and Lachish

Lachish also shared close affinity with the Phoenician sample (MMD value of 0.025) from Carthage (CAR). The site of Carthage, in Northern Africa, is thought to have been occupied by Phoenicians from 751–146 B.C.E. (Charles-Picard & Picard 1968). Phoenicians are biologically and culturally derived from Canaanites, the latter of whom occupied Lachish for several generations (Mazar, 1992; Ussishkin, 2004; Tufnell, 1958). The Phoenician presence indicated by the MMD values is expected, and further suggest continuity from at least the period of Canaanite occupation at Lachish.

Nubia and Lachish

Lastly in the group that is most similar to Lachish, are Pharonic (PHA) Nubians (MMD value of 0.00) in Upper Egypt and Northern Sudan (Irish, 2005). Several studies suggest (Newman, 1995; Williams, 1997; Irish, 2005) that Pharonic Nubians were likely a group of Egyptians who immigrated during the Egyptian New

Kingdom (1550-1070 B.C.E.) expansion (Phillipson, 1994; Newman, 1995; Williams, 1997; Irish, 2005). Irish (2005) conducted a dental nonmetric study investigating Nubian population origins and affinities. In this study, he tested long standing conflicting hypotheses postulating that either the Pharonic individuals were C-group Nubians assimilated into Egyptian culture, or they were in fact Egyptian immigrants. Irish concluded that with a highly divergent MMD score of 0.117, the C-group Nubians and the Pharonic individuals excavated from the same confined geographic area are significantly different, thus supporting the Egyptian immigrant hypothesis (Irish, 2005). If the Pharonic Nubians were indeed Egyptian immigrants, their close affinity with the individuals of Lachish would not be unexpected.

Is the ancient Lachish populace dentally similar to other groups in the Mediterranean Diaspora, and if so, with whom do they have greater biological affinity?

In order to better understand how the individuals of the Lachish sample fit in dentally with other Mediterranean groups, MMD values from a subset of the original comparative samples were analyzed. Of the samples used in the study, Lachish (LCB, LCI), Italian (ITY), Greek (GRK), Turkish (TRK), some Egyptians (LIS, GIZ, TAR, SAQ), Phoenicians (CAR), and certain North Africans (SHA, KAB, BED) can generally be considered "Mediterranean" area populations based on their proximity to the Mediterranean Sea. The Iron Age Lachish populace is dentally similar in varying degrees to all of the Mediterranean groups included in the study. To reiterate, low

MMD scores indicate greater affinity, so GIZ, LIS, and CAR with a mean MMD score of 0.022 have the closest affinity with LCI than any of the other Mediterranean groups. With the exception of SAQ in the third most similar, the remaining samples ITY, GRK, TRK, TAR, SHA, KAB, BED are in the group second most similar to LCI with a mean MMD score of 0.052.

Although SAQ, SHA, KAB, BED, ITY are similar to LCI, they are significantly different, and represent the sample populations with the least affinity to LCI among the represented Mediterranean samples (see Table 8 for MMD scores). The SAQ sample, as mentioned previously, is a Lower Egyptian sample dated to the Fourth Dynasty. General information about the excavation indicates that the sample is comprised of royal or elite individuals. Significant divergence from LCI may reflect genetic drift and/or inbreeding in this royal-class social group (Bayfield, 2000; Malek, 2000; Grajetzki and Quirke, 2001; Irish, 2006). The SHA sample consists of historic Shawia Berber individuals from Algeria. Shawia Berbers in this region show evidence of admixture with Carthaginians, Greeks, Romans, Spanish, Turkish and French populations. Due to the later time period, and high level of heterogeneity, the significant divergence from LCI is not unexpected (Guatelli-Steinberg et al., 2001). The KAB sample is similarly composed of historic Berber individuals from Algeria. Unlike SHA, however, the Kabyle Berbers were fairly isolated with little admixture from outside groups. Therefore, significant divergence from LCI is not unexpected (Guatelli-Steinberg et al., 2001). Historic Bedouin Arabs admixed with Berbers comprise the BED sample. Lastly, ITY is comprised of historic and Roman Italian individuals. Again, for both BED and ITY, partially due to the temporal difference between LCI and BED, and mainly due to the admixture between populations not accounted for in Canaan, the significant divergence is not unexpected (Guatelli-Steinberg et al., 2001; Irish, personal communication, 2012).

Within the Mediterranean subgroup of samples, LCI has the greatest affinity with the samples Lisht, Giza, and Carthage, which as mentioned earlier, are not unexpected results. The latter indicate that of all the Mediterranean groups represented, Lachish maintains a stronger Egyptian and Phoenician affinity, with European and North African affinities secondarily. Figure 6 illustrates the affinity between LCI and the Mediterranean sample represented in the comparative samples.

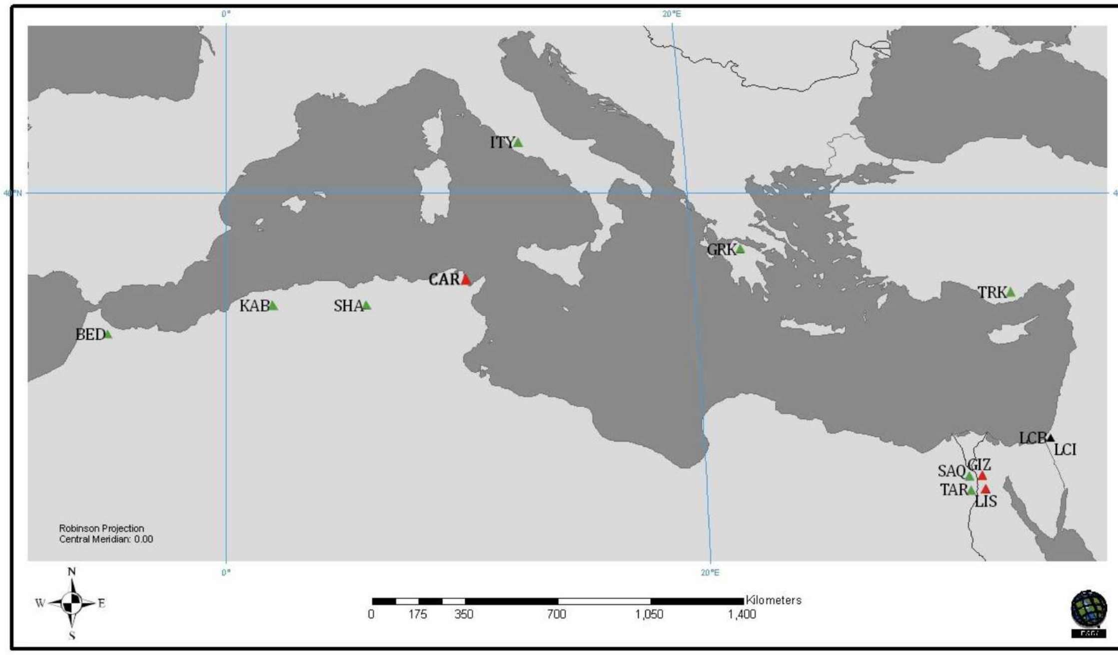


Figure 6. Map showing affinity between LCI and the Mediterranean comparative samples. The red triangles represent the groups most similar to LCI, while the green triangles represent the groups second most similar to LCI.

Isolation-by-distance

To assess how much, if any, other populations contributed to the biological make-up of the Lachish population, the isolation-by-distance stepping stone model was tested. The Pearson's R Correlation Coefficient value and significance value indicate that the isolation-by-distance model does not fit the data (see Table 9); suggesting there is no significant correlation between geographic distance and phenetic distance. A few groups, however, fall into the 95% confidence interval, meaning that these groups fit the isolation-by-distance model with .95 certainty (See Figure 4). These groups are KAW, KER, KUS, PHA, and SOL; Egyptian and

Nubian groups whose relatively close phenetic and geographic distances are expected to fit the model. Most of the groups, however, do not fit.

There are several possible reasons the data does not fit the model. Firstly, many cultural/ethnic groups including Canaanites, Egyptians, Assyrians, Babylonians, and Hebrews have occupied Lachish during its long existence. Thus, most of the positive gene flow into Lachish likely came from the dominating regional power groups, independent of geographic proximity, rather than neighboring groups within a close geographic proximity. Secondly, Mediterranean groups have long been known to cross the sea in order to colonize and settle new regions (Bar-Yosef, 2003). The Phoenicians, for example, while originating in Palestine, founded Carthage in North-West Africa. So, while the individuals in the CAR sample are geographically distant from the individuals at Lachish, they are biologically similar, thereby not fitting the isolation-by-distance model.

Similarly, the Greek sample (GRK) is biologically closer to LCI than geographically, thus not fitting the model. The Philistines, who are thought to represent a group of Mycenaean Greeks, immigrated to Palestine at the end of the 13th century B.C.E, and through their Mycenaean IIIC1b pottery, are well documented in the region (Furumark, 1941 a, b). The Philistines settled in Canaan, rejected Egyptian authority and became prosperous and long-term residents in Palestine (Mazar, 1992; Finkelstein, 1996). Interestingly, no appreciable Philistine pottery has been recovered at Lachish, leading many regional experts to doubt their presence in the city (Finkelstein 1995, 1996: 179-80, 1998; Ussishkin 1985, 1993). There is a possibility that the affinity between LCI and GRK is actually representative of an affinity between LCI and the Philistines, which may indicate a significant Philistine occupation in Lachish after all. Keita (1988:388) in his craniometric study on the Lachish series states the following:

> It is possible to say that the objective evidence does not deny an hypothesis of biological heterogeneity in some general sense at Lachish, which specific historical and archaeological data unequivocally predict. It is suggested that the Egypto-Nubian presence is supported.

Data reflecting biological heterogeneity within a population will generally not fit an isolation-by-distance model. Especially when the heterogeneity is born of positive gene flow from conquering groups, not neighboring groups. Figure 7 indicates the site location of all the samples. Figures 7a, the Egyptian and Nubian samples star diagram, and 7b, the North African and European samples star diagram, are heuristic figures that illustrate the relationship between the MMD scores and the geographic locations of the samples. The lines on the maps represent the MMD values between LCI and each of the comparative samples. The length of each line is a ratio of the MMD score and the Euclidian map distance between sites in centimeters (the maps do not visualize absolute relationships because the line, which represents phenetic distance, is dependent on geographic distance, which is relative to map scale and projection). If a line originating at Lachish overshoots its affiliated site, then the sample from that site is generally considered to be closer geographically than phenetically. Similarly, if a line does not reach its intended site, then the corresponding sample is considered to be more phenetically close than geographically.

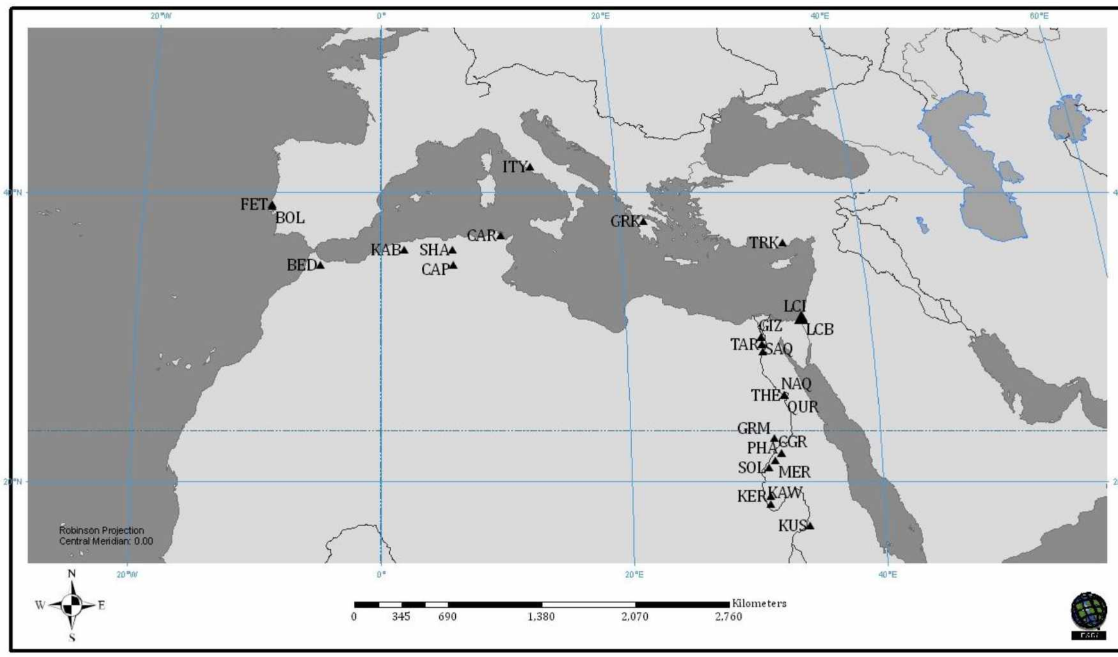


Figure 7. Map of sites.

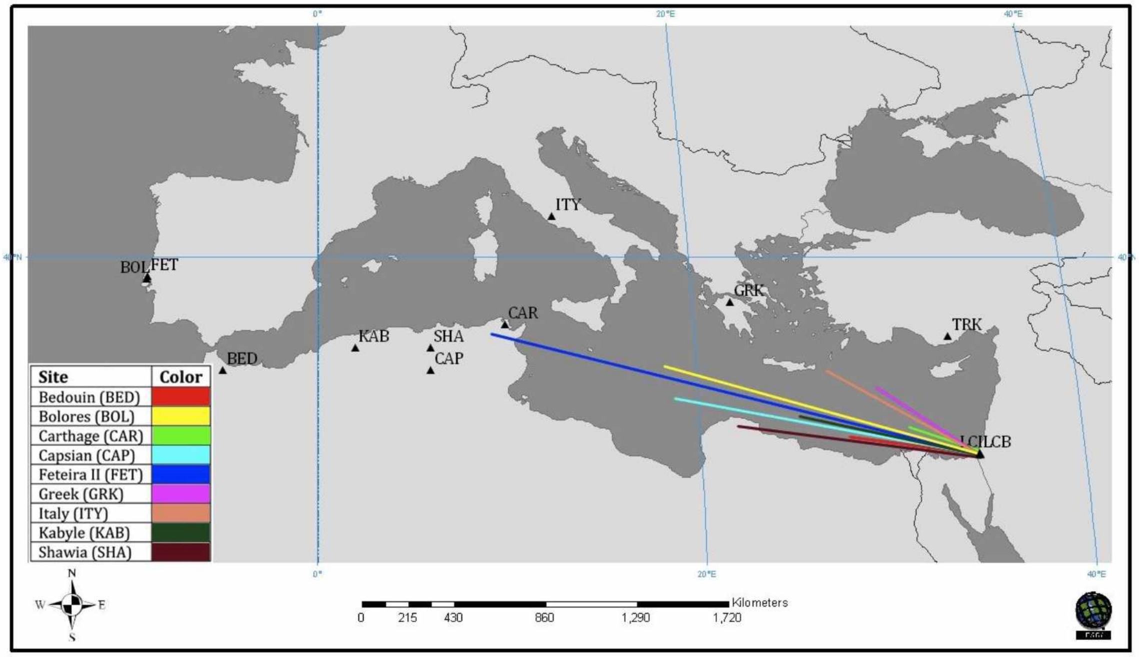


Figure 7a. Star diagram of North African and European MMD and geographic distances.

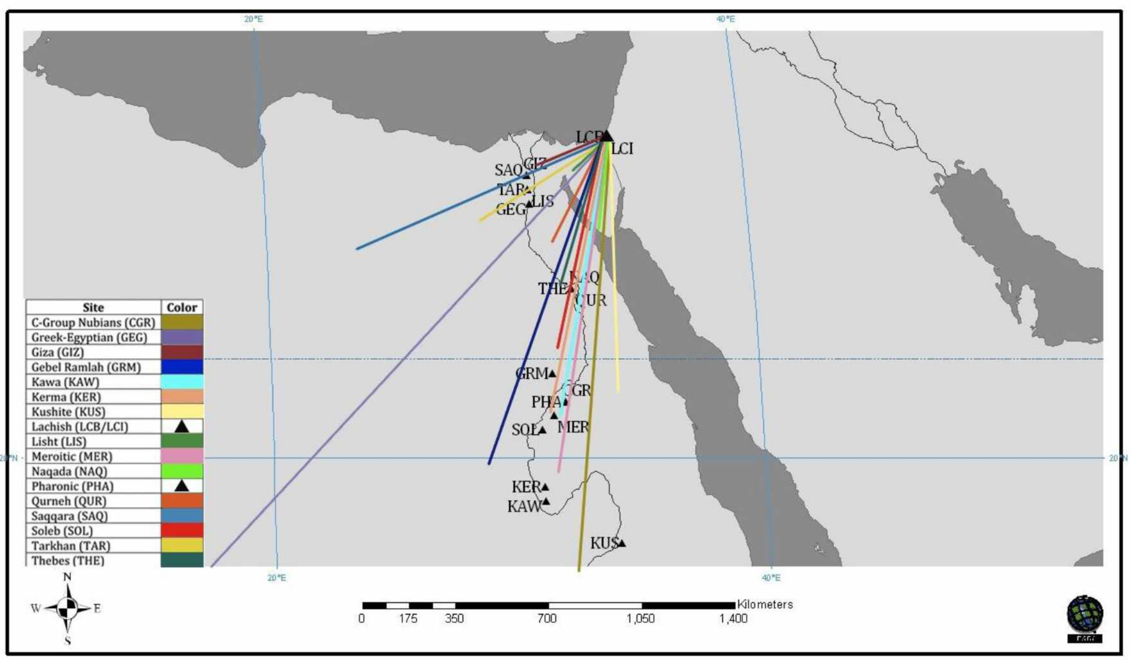


Figure 7b. Star diagram of Egyptian and Nubian MMD and geographic distances.

Who are the peoples of ancient Lachish?

As previously stated, researchers for approximately 80 years have been attempting to identify the ancient peoples of Lachish. As such, many proposed hypotheses accounting for the identity of the Late Bronze and Early Iron Age inhabitants have been proposed. Outlined here are the four common hypotheses proposing the identity of the Lachish Late Bronze and Early Iron Age inhabitants as discussed in Chapter 3, accompanied by a discussion of how the current results support or refute each hypothesis:

***1. "The Israelite Conquest"*-(replacement). Skeletons of the Late Bronze Age represent defeated Canaanites and the Early Iron Age skeletons represent individuals of the 'Israelite Conquest' who came to occupy Lachish (Albright, 1939; Stager, 1985; Redford, 1992; Holladay, 1995).** While material evidence of the Israelites occupation in Iron Age levels at Lachish is conclusive, the exact timing and mode of arrival is completely unknown (Finkelstein, 1995b, 1996). The evidence of biological continuity between the individuals of the Bronze and Iron Age skeletal samples indicate that individuals of the Israelite Conquest did not replace the previous inhabitants. Therefore, "The Israelite Conquest" hypothesis is not supported here.

***2. "Victims of Battle"*- (continuity). The Early Iron Age skeletal collection is comprised of victims of a battle with Assyria that likely took place at Lachish in 701 B.C.E. (Tufnell, 1953; Ussishkin, 1982, 1990; Mazar, 1992;).** Less than

1% of the skeletons of the Lachish Iron Age collection possess observable fatal injuries. If the collection were the victims of the Assyrian battle, one would expect to see a significantly higher percentage of battle-associated injuries (i.e. high percentages of blunt force trauma etc.). Therefore, the "Victims of Battle" hypothesis is not supported here.

3. "Immigration"- **(replacement). The skeletons of the Iron Age collection represent an unknown immigrant group (Israelite, Egyptian, Philistine, etc.) who replaced the previous Canaanite Bronze Age population (Risdon, 1939; Finkel, 1976, 1978; Redford, 1992; Dever, 1995a,b).** While a level of heterogeneity is supported, and while immigrants, over time, certainly contributed biologically to the Lachish populace, the "Immigration" hypothesis is rejected here. Continuity between the individuals of the two periods does not lend support to complete replacement by an immigrant population between the Bronze and Iron Age.

4. "Biological Continuity"- **(continuity). The Iron Age individuals in the collection represent descendants of the Late Bronze Age individuals, suggesting that any cultural change can be explained by changing political, economic, and social circumstances in Ancient Palestine as a whole (Finkelstein, 1995b, 1996; Ussishkin, 2004; Ullinger et al., 2005).** The research presented here supports the *"Biological Continuity"* hypothesis. The Iron Age individuals in the collection represent descendants of the Late Bronze Age individuals, indicating that cultural change can be attributed to changing political, economic, and social circumstances in Ancient Palestine (Finkelstein, 1995b, 1996; Ussishkin, 2004; Ullinger et al., 2005). The results here suggest that the cultural transition does not reflect a biological transition. Change was likely a slow and complex process involving cultural and biological assimilation between Egyptians, Canaanites and Israelites (and possibly Philistines, Phoenicians, Samarians, and the Sea Peoples) over many generations (Finkelstein, 1995a,b, 1996; Ussishkin, 2004; Ullinger et al, 2005).

CHAPTER 8- CONCLUSIONS AND FUTURE RESEARCH

The transition between the Late Bronze and Early Iron Ages in Palestine was a period of intense cultural and political change (Mazar, 1992; Golden, 2004; Ussishkin, 2004). Generations of Egyptian sovereignty, in-migration, and the diversification of practices by the indigenous peoples resulted in a landscape with varying and rapidly evolving cultural groups, changing economic and subsistence strategies, and political unrest (Ben-Tor, 1992; Mazar, 1992; Byrne, 2002; Bar-Yosef, 2003; Golden, 2004; Ussishkin, 2004).

At the site of Lachish, in southern Palestine, the turbulence of the greater region is reflected, and can be observed in the archaeological record. Partly because Lachish was situated near major roads in the South and was developed on fertile soils in a moderate climate, the city became a large cosmopolitan center (Ussishkin, 2004). Several foreign political groups dominated the city over time, including Canaanites, Egyptians, Hebrews, Assyrians and Babylonians, each one leaving cultural material influence. The Hebrews, a cultural group who came to occupy much of Palestine in the Iron Ages, became the dominant peoples of Lachish by the Early-Middle Iron Age, as seen by a distinct material culture change in the archaeological record (Tufnell, 1950, 1970). Due to biblical zeal and some unclear archaeological interpretations, how and when the Hebrews came to occupy the previously Canaanite city became questions of great controversy. One question in particular is difficult or impossible to address using archaeological interpretations alone: does the documented Hebrew presence in the Iron Age at Lachish represent an in-migration of Hebrew peoples, or the adoption of Hebrew cultural attributes by the local Canaanite peoples?

Archaeologists in the early 20th century excavated over 1500 individuals at Lachish. Skeletons recovered from the site were dated to both the Late Bronze Age and the Early Iron Age, seemingly framing the volatile and debated transitional period (Risdon, 1939; Tufnell, 1950). With the discovery of these skeletons came the potential for research using biological methodologies to address questions of how and when the Hebrew culture came to dominate the Canaanite culture at Lachish. Multiple studies on the skeletons have been performed, most attempting to biologically identify the individuals of both periods. The conclusions of the studies have been varied and in all, inconclusive (Risdon, 1939; Berry and Berry, 1972; Finkel, 1976, 1978; Musgrave and Evans, 1981; Keita, 1988; Ullinger et al., 2005).

The primary purpose of the research presented here is to assess if the Bronze and Iron Age individuals from the Lachish skeletal collection are biologically continuous. A biologically continuous population between the periods implies cultural assimilation. Discontinuity between the individuals of each period suggests biological assimilation or replacement of the Bronze Age populace by a distinct Iron Age group. A hypothesis of biological continuity was tested using the Arizona State University Dental Anthropology System to investigate phenetic affinity between the Bronze and Iron Age skeletal samples. A divergent affinity (discontinuity) between the samples of the two periods would suggest two distinct biological populations are represented. A close affinity (continuity) between the samples would suggest one biological population is represented.

Phenetic affinity is assessed here based on dental morphological similarities between the samples of the Bronze and Iron Age. Using C.A.B. Smith's Mean Measure of Divergence, a distance statistic that provides a quantitative estimate of inter-sample biological distance based on similarities among traits, phenetic continuity between the Bronze and Iron Age individuals of the Lachish sample was demonstrated with an MMD score of 0.00 (Irish, 2010). Therefore, according to the research presented here, the cultural change documented between the Bronze and Iron Age at Lachish was primarily due to cultural assimilation, not biological assimilation between the Canaanites (Bronze Age) and Hebrews (Iron Age) of Lachish.

A secondary objective addressed in this study was to assess the dental affinity of the Lachish samples with other Mediterranean samples. Comparative samples (n=26) from European and African groups were used to estimate biological affinity of the Lachish sample within the Mediterranean area, Egypt and Nubia. Each sample was chosen due to its temporal designation or because of its proximity to the Mediterranean Sea, Egypt or Nubia.

Within the Mediterranean subgroup of samples, LCI has the greatest affinity with the samples Lisht, Giza, and Carthage, which as mentioned earlier, are not unexpected results. The latter indicate that of all the Mediterranean groups represented, Lachish maintains a stronger Egyptian and Phoenician affinity, with European and North African affinities secondarily.

To assess how much the comparative sample populations may have contributed to the biological make-up of the Lachish population, the isolation-by-distance linear stepping stone model was tested. The Pearson's R Correlation Coefficient value and significance value indicate that the isolation-by-distance model does not fit the data; suggesting there is no significant correlation between geographic distance and phenetic distance.

There are several possible reasons the data does not fit the model. Most of the positive gene flow into Lachish likely came from the dominating regional power groups, independent of geographic proximity. Secondly, Mediterranean groups have are known to have crossed the sea in order to colonize and settle new regions (Bar-Yosef, 2003).

Based on the research presented here, and that of previous studies (Keita, 1988; Finkelstein, 1995a,b, 1996; Ussishkin, 2004; Ullinger et al., 2005), the ancient populace of Lachish during the Late Bronze Age were likely people of mixed Canaanite and Egyptian (and possibly Philistine) ancestry. With the coming of the Israelites, the Iron Age populace of Lachish likely assimilated, both culturally and biologically, with the new immigrants.

In summary, the present study of population affinities based on dental morphology demonstrates an Egyptian and Phoenician presence (the latter most likely reflecting Canaanite ancestry) is supported, specifically when compared to the Mediterranean sub-group represented in the study. Biological heterogeneity in the sample is supported by both the MMD values and the correlation coefficient.

In the future, a dental morphological study including samples of regional populations, specifically those of Philistine and Israelite descent would reveal a more finite picture of the biological make-up of the Lachish sample. A more detailed heterogeneity investigation, whereby phenetic distance between individuals in the collection is analyzed would also yield more specific results. Furthermore, genetic and isotopic analysis would be extremely useful in investigating heterogeneity, continuity and/or migrations of the ancient populace of Lachish. Lastly, nonmetric dental, genetic and isotopic studies of samples from sites surrounding Lachish would increase regional knowledge and provide context for the Shephelah and greater geographic region.

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APPENDIX 1

COMPLETE INVENTORY OF THE LACHISH SKELETAL COLLECTION AT THE BRITISH MUSEUM OF NATURAL HISTORY.

Numbers 1-730 are Iron Age crania, and 731-776 are Bronze Age crania. The number 1 in the "teeth" column indicates the presence of at least one associated tooth.

# of indiv.	Cranium catalogue #	teeth	Tomb
1	1	1	120
2	2	1	120
3	3	1	120
4	4	1	120
5	5	1	120
6	6	1	120
7	7	1	120
8	8	1	120
9	9	1	120
10	10	1	120
11	11	1	120
12	12	1	120
13	13	1	120
14	14	1	120
15	15	1	120
16	16	1	120
17	17		120
18	18	1	120
19	19	1	120
20	20	1	120
21	21	1	120
22	22	1	120
23	23	1	120
24	24	1	120
25	25	1	120

26	26		120
27	27	1	120
28	29	1	120
29	30	1	120
30	31	1	120
31	32	1	120
32	33		120
33	34		120
34	35	1	120
35	36	1	120
36	37	1	120
37	38	1	120
38	39	1	120
39	40	1	120
40	41		120
41	42	1	120
42	43		120
43	44		120
44	45		120
45	46	1	120
46	47	1	120
47	48	1	120
48	49	1	120
49	50	1	120
50	51	1	120
51	52	1	120
52	53	1	120
53	54	1	120
54	55	1	120
55	56	1	120
56	57	1	120
57	58	1	120
58	59	1	120
59	60		120
60	61	1	120
61	62	1	120
62	63		120
63	64	1	120

64	65		120
65	66	1	120
66	67	1	120
67	68		120
68	69	1	120
69	70		120
70	71	1	120
71	72	1	120
72	73	1	120
73	74		120
74	75	1	120
75	76		120
76	77		120
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83	84	1	120
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86	87		120
87	88	1	120
88	89	1	120
89	90	1	120
90	91	1	120
91	92	1	120
92	93	1	120
93	94	1	120
94	95		120
95	96		120
96	97	1	120
97	98	1	120
98	99		120
99	100	1	120
100	101	1	120
101	102	1	120

102	103	1	120
103	104	1	120
104	105	1	120
105	106	1	120
106	107		120
107	108		120
108	109		120
109	110		120
110	111	1	120
111	112	1	120
112	113	1	120
113	115	1	120
114	116	1	120
115	117		120
116	118		120
117	119	1	120
118	120	1	120
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120	122	1	120
121	123	1	120
122	124	1	120
123	125	1	120
124	126	1	120
125	127	1	120
126	128	1	120
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129	131	1	120
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132	134	1	120
133	135	1	120
134	136	1	120
135	137	1	120
136	138		120
137	139	1	120
138	140	1	120
139	141	1	120

140	142	1	120
141	143	1	120
142	144		120
143	145		120
144	146	1	120
145	147	1	120
146	148	1	107B
147	149		107B
148	150	1	107B
149	151	1	107B
150	152	1	107
151	153	1	107
152	154	1	107B
153	155	1	107
154	156	1	107
155	157		107B
156	158	1	107B
157	159	1	107B
158	160		107B
159	161		107B
160	162	1	107B
161	163	1	107
162	164	1	107B
163	166	1	107B
164	167	1	107B
165	168	1	107B
166	169	1	107B
167	170		107B
168	171	1	107
169	172	1	107C
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186	192		106
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475	483	1	107B
476	484	1	107B
477	486	1	107
478	487	1	107B
479	488	1	107B
480	489		107B
481	490	1	107B

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484	494	1	107B
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487	497	1	107
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685	691	1	107B
686	692	1	107C
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695	702	1	120
696	703	1	120
697	704	1	107B
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732	802		4005
733	803	1	4005
734	804	1	6006
735	805	1	6009B
736	806	1	6013G
737	807	1	239
738	809	1	6027B
739	810		508
740	811		508B
741	812	1	508
742	813		4005
743	814	1	4005
744	815		4005
745	816	1	6009A
746	817		4005
747	818	1	4005

748	819	1	4005
749	820	1	4005
750	821	1	6013L
751	822	1	4029
752	823	1	4029
753	824	1	6027C
754	825	1	6028A
755	826	1	6028E
756	827		4005
757	828		4029
758	829	1	4002A
759	830	1	6009A
760	831	1	6027
761	832		6028C
762	833	1	6028G
763	834		1004
764	835		4011
765	836		6028K
766	837	1	6028L
767	838	1	6028F
768	839	1	6028D
769	840	1	6028B
770	841	1	6028J
771	842	1	6028H
772	843	1	4005
773	844	1	508A
774	845		4001
775	846		508
776	847	1	501

APPENDIX 2

DESCRIPTIONS OF COMPARATIVE SAMPLES USED IN THE STUDY.

The Bedouin Arab (BED) sample is comprised of historic crania (19-20th century AD) from Morocco, Algeria, Tunis and Libya. This sample is believed to be admixed Arabs and Berbers. The sample is housed at Musée de l'Homme and the University of Minnesota (Julien 1970; Hiernaux 1975; Guatelli-Steinberg et al., 2001).

The Bolores (BOL) sample consists of prehistoric individuals (2800-1800 BC) from the Estremadura region of Portugal. The individuals are thought to have been agriculturalists and are not affiliated with a known habitation site. The individuals were excavated in a rock shelter burial and are stored at the University of Iowa (Lillios et al., 2010).

The Capsian sample (CAP) contains individuals excavated from Algerian and Tunisian sites and are housed at the University of Minnesota, University of Alberta, and Institut de Pale´ ontology Humaine. . The remains appear to be somewhat heterogenous and are apparently associated with the Typical (**n** =2 inds), Upper (**n** =12), and Neolithic of Capsian Tradition (**n** =8) industries (Chamla, 1973; Camps, 1974 ; Sheppard, 1987; Irish, 2000).

The sample from Carthage (CAR) consists of Punic (751–146 B.C.E) and Roman (146 B.C.E-435 AD) period individuals excavated at the site of Carthage, Tunisia and are housed at Musée de l'Homme. The site was founded by Phoenicians in 751 B.C.E and later conquered by Romans (Charles-Picard & Picard 1968; Guatelli-Steinberg et al., 2001).

The C-Group Nubians (CGR) (2000 –1600 B.C.E) were excavated by Scandinavian Joint Expedition members between Egypt's Faras district in the north and Gamai, Sudan in the south. C-Group Nubians were semi-nomadic, but practiced animal domestication and agriculture (Nielsen, 1970; Irish, 2005).

Feteira II (FET) sample consists of prehistoric individuals from the Estremadura region of Portugal. The individuals are thought to have been agriculturalists and are not affiliated with a known habitation site. The individuals were excavated from a collective burial cave and are stored at the University of Iowa (Waterman, 2006).

The Ptolemaic or Greek period Egyptian sample (GEG) is comprised of individuals excavated from Saqqara, and Manfalut in Egypt. The sample is potentially heterogenous and is dated to 332-330 B.C.E. No additional information is available (Irish, 2006).

Samples recovered at Giza (GIZ) are affiliated with the Late Dynastic period and are from Lower Egypt. No additional information is available (Irish, 2006; Petrie, 1907; Pearson and Davin, 1924).

The Greek sample (GRK) is affiliated with Classic and historic periods. The sample is comprised of heterogeneous individuals excavated from Greece and Crete, and are housed at the American Museum of Natural History (Irish, personal communication, 2011).

The Gebel Ramlah (GRM) sample consists of individuals dated to the Final Neolithic (ca 5740-5555 +/- 60), and excavated from Gebel Ramlah, Lower Nubia by members of the Combined Prehistoric Expedition. The peoples of Gebel Ramlah were semi-nomadic peoples who seasonally migrated between the desert and Nile, or other well watered locations (Wendorf and Schild, 2001; Irish, 2005).

The Italian sample (ITY) are comprised of historic and Roman period individuals. The collection is housed at the Natural History Museum London.

No further information is available (Irish, personal communication, 2011).

The Kabyle Berber (KAB) sample is composed of historic crania housed at the Musée de l'Homme. The individuals were excavated from northern Algeria. The group was considered isolated with little genetic admixture from outside groups (Wysner, 1945; Guatelli-Steinberg et al., 2011).

The Kawa sample (KAW) consists of individuals dating to the Kerma Ancien and Moyen periods, excavated by the Sudan Archaeological Research Society near Kawa, on the Nile's east bank (Judd, 2001; Welsby, 2001; Irish, 2005).

The Kerma sample (KER) is affiliated with the Kerma Classique culture, and was excavated near the Third Cataract; it was collected by Reisner and associates for the joint Harvard University and Boston Museum of Fine Arts Expedition (Reisner, 1923; Collett, 1933; Irish, 2005).

The Kushite sample (KUS) comprises early Meroitic specimens from Kawa, and later Meroitic through post-Meroitic remains from Gabati (Edwards et al., 1998), in extreme southern Nubia. The Sudan Archaeological Research Society excavated both sites. The sample is heterogenous and compiled to allow some representation of post-Kerma Upper Nubians, for whom few dental data exist (Irish, 2005).

The Lisht sample (LIS) (1985–1773 B.C.E) is an upper-class social group from Itjtawy, Lower Egypt, which may also comprise elite immigrants from the latter region. The Egyptian capital and ruling class were moved from Thebes to Itjtawy in the 12th Dynasty. (Johnson and Lovell, 1994; Prowse and Lovell, 1996; Irish, 2006).

The Meroitic sample (MER) consists of specimens excavated from Lower Nubia and are dated to 100 B.C.E-AD 350. The remains were excavated by Scandinavian Joint Expedition members (Nielsen, 1970), as well as by workers from the Oriental Institute and University of Chicago near Semna, Sudan (Zabkar and Zabkar, 1982). The remains are housed at Arizona State University (Irish, 2005).

The Naqada sample (NAQ) is an Upper Egyptian group from three later predynastic cemeteries thought to vary by social status (Johnson and Lovell, 1994); it was excavated by Flinders Petrie for a British School of Archaeology expedition (Petrie and Quibell, 1896; Warren, 1897; Fawcett, 1902). All but three specimens in this sample are affiliated with the lower class (Irish, 2006).

The Pharonic sample (PHA) Nubians were recovered by Scandinavian Joint Expedition members (Nielsen, 1970), among others, between Egypt's Faras district in the north, and Gamai, Sudan in the south. The individuals were likely Egyptian immigrants in Nubia (Irish, 2006).

The Qurneh sample (QUR) was excavated in a New Kingdom cemetery near a mortuary temple in Upper Egypt (Petrie, 1909). E.W. Budge excavated it in 1887. Most specimens recorded for the present study date to the time of Rameses II; a few are of the later New Kingdom or early Third Intermediate period (Irish, 2006).

The Saqqara sample (SAQ) is comprised of remains from Saqqara and dates to the Old Kingdom's Fourth Dynasty. General information about the cemetery implies that the sample may have originated from royal or wealthy elite tombs in North Saqqara (Bayfield, 2000;Malek, 2000; Grajetzki and Quirke, 2001; Irish, 2006).

The Shawia Berber (SHA) sample consists of the remains historic individuals, excavated from south of Constantine, Algeria and is housed at the Musée de l'Homme. Shawia Berbers in this region show evidence of admixture with other peoples including Carthaginian, Greek, Roman, Spanish, Turkish and French (Guatelli-Steinberg et al., 2001).

The Soleb sample (SOL) is from an 18th Dynasty Pharonic necropolis at Soleb in Upper Nubia. The sample was excavated by Schiff-Giorgini for a joint French-Italian expedition (Billy and Chamla, 1981; Irish, 2005).

The Tarkhan sample (TAR) is from Tarkhan in Lower Egypt and date to the Early Dynastic. Little other information is known (Irish, 2006).

The Thebes sample (THE) was collected in 1904 as part of the Felix von Luschan Collection. The excavation was in Thebes, Upper Egypt and is generally dated to the Middle Kingdom (Irish, 2006). Due to lack of excavation records, no other information is known.

The Turkey sample (TRK) is a heterogeneous collection, mostly dated to 300 B.C.E. The collection is housed at the American Natural History Museum (Irish, personal communication, 2012).

APPENDIX 3

MORPHOLOGICAL FEATURES OF THE CROWNS AND ROOTS

Maxillary Features

Winging

1. *Bilateral winging:* Central incisors are rotated mesiolingually, giving a V-shaped appearance when viewed from the occlusal surface. When the angleformed is greater than 20 degrees, it is classed as IA; when less than 20 degrees, lB.
2. *Unilateral winging:* Only one of the incisors is rotated. The other is straight. No subclasses are recognized.
3. *Straight:* Both teeth fonn a straight labial surface, or follow the curvature of the dental arcade.
4. *Counter-winging:* One or both teeth are rotated distolingually.

Shoveling

0. *None:* Lingual surface is essentially flat.
1. *Faint:* Very slight elevations of mesial and distal aspects of lingual surface can be seen and palpated.

2. *Trace:* Elevations are easily seen. This grade is probably considered minimal expression by most observers.
3. *Semishovel:* Stronger ridging is present and there is a tendency for ridge convergence at the cingulum.
4. *Semishovel:* Convergence and ridging are stronger than in grade 3.
5. *Shovel:* Strong development of ridges, which almost contact at the cingulum.
6. *Marked shovel:* Strongest development. Mesial and distal lingual ridges are sometimes in contact at the cingulum.
7. *(U12 only) Barrel:* Expression exceeds grade 6. To be considered barrel-shaped, the form should not result from a hypertrophied tuberculum dentale.

Labial Convexity

0. Labial surface is flat.
1. Labial surface exhibits trace convexity.
2. Labial surface exhibits weak convexity.
3. Labial surface exhibits moderate convexity.
4. Labial surface exhibits pronounced convexity.

Double-shoveling

0. *None:* Labial surface is smooth.
1. *Faint:* Mesial and distal ridging can be seen in strong contrasting light. Distal

ridge may be absent in this and stronger grades.

2. *Trace:* Ridging is more easily seen and palpated.
3. *Semi-double-shovel:* Ridging can be readily palpated.
4. *Double-shovel:* Riding is pronounced on at least one-half of the total crown height.
1. *Pronounced double-shovel:* Ridging is very prominent and may occur from the occlusal surface to the crown-root junction.
2. *Extreme double-shovel.*

Interruption Groove

1. None. The mesial, distal, and medial areas of the lingual surface of the incisor are smooth, continuous, and not disrupted by any vertical to near-horizontal groove.

M. An interruption groove occurs on the mesiolingual border.

D. An interruption groove occurs on the distolingual border.

MD. Grooves occur on both the mesio- and distolingual borders.

Med. A groove occurs in the medial area of the cingulum.

Tuberculum Dentale

0. No expression. Cingular region of the lingual surface is smooth. Ignore any shoveling presence.

1. Faint ridging. Matches grade I of the ASU UI I t.d. plaque.
2. Trace ridging. Matches grade 2 of the ASU UII t.d. plaque.
3. Strong ridging. Matches grade 3 of the *ASV* UII t.d. plaque.
4. Pronounced ridging. Matches grade 4 of the ASU UII t.d. plaque.

5 - A weakly developed cuspule is attached to either the mesio- or distolingual marginal ridge. Cuspule apex is not free. Not represented on a plaque. Interpolate between ASU UIl t.d. grade 4 and the tuberculum dent ale found on ASU UC DAR grade 4.

5. Weakly developed cuspule with a free apex. Size corresponds approximately with ASU UC DAR grade 4 tuberculum dentale.
6. Strong cusp with a free apex . Size is equal to or greater than the ASU *VC* DAR grade 5 tuberculum dentale .

Canine Mesial Ridge

0. Mesial and distal lingual ridges are the same size. Neither is attached to the tuberculum dentale if present.
1. Mesiolingual ridge is larger than the distolingual, and is weakly attached to the tuberculum dentale.
2. Mesiolingual ridge is larger than the distolingual, and is moderately attached to the tuberculum dentale.
3. Morris's type form . Mesiolingual ridge is much larger than the distolingual,

and is fully incorporated into the tuberculum dentale.

Canine Distal Accessory Ridge

0. Distal accessory ridge is absent.
1. Distal accessory ridge is very faint. (No example of grade 1 appears on the UC plaque, interpolation required.)
2. Distal accessory ridge is weakly developed.
3. Distal accessory ridge is moderately developed.
5. Distal accessory ridge is strongly developed.
6. Distal accessory ridge is very pronounced.

Premolar Mesial and Distal Accessory Cusps

0. No accessory cusps occur.
1. Mesial and/or distal accessory cusps are present.

Tricusped Premolars

1. Extra distal cusp *(hypocone)* is absent.
2. Hypocone is present. Its size equals that of the normal lingual cusp.

Distosagittal Ridge:

1. Normal premolar form occurs.
2. Distosagittal ridge is present.

Metacone

0. Metacone is absent.
1. An attached ridge is present at the metacone site, but there is no free apex.
2. A faint cuspule with a free apex is present.
3. Weak cusp is present.

3.5. An intermediate-sized cusp is present (not shown on plaque, interpolation necessary) .

4. Metacone is large.
5. Metacone is very large (equal in size to a large M1 hypocone).

Hypocone

0. No hypocone. Site is smooth.
1. Faint ridging present at the site.
2. Faint cuspule present.
3. Small cusp present.

3.5. Moderate-sized cusp present.

4. Large cusp present.
5. Very large cusp present.

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Cusp 5 (Metaconule)

0. Site of cusp 5 is smooth, there being only a single distal groove present

separating cusps 3 and 4.

1. Faint cuspule is present.
2. Trace cuspule present.
3. Small cuspule present.
4. Small cusp present.
5. Medium-sized cusp present.

Carabelli's Trait

0. The mesiolingual aspect of cusp 1 is smooth.
1. A groove is present.
2. A pit is present.
3. A small Y -shaped depression is present.
4. A large Y -shaped depression is present.
5. A small cusp without a free apex occurs. The distal border of the cusp does not contact the lingual groove separating cusps I and 4.
6. A medium-sized cusp with an attached apex making contact with the medial lingual groove is present.
7. A large free cusp is present.

Parastyle

0. The buccal surfaces of cusps 2 and 3 are smooth.

1. A pit is present in or near the buccal groove between cusps 2 and 3.
2. A small cusp with an attached apex is present.
3. A medium-sized cusp with a free apex is present.
4. A large cusp with a free apex is present.
5. A very large cusp with a free apex is present. This form usually involves the buccal surface of both cusps 2 and 3.
6. An effectively free peg-shaped crown attached to the root of the third molar is present. This condition is extremely rare , and is not shown

0. on the plaque.

Enamel Extensions

0. Enamel border is straight, or rarely curved towards the crown. Score any extension *not* attached to the crown as absent.
1. A faint, approximately 1.0-mm-long extension projecting toward and along the root.
2. A medium-sized, approximately 2.0-mm-long extension.
3. A lengthy extension, generally > 4.0 mm in length is present. It may extend all the way to the root bifurcation on molar teeth.

Premolar Root Number

1. *One root:* Tip may be bifurcated *(bifid).*
2. *Two roots:* Separate roots must be greater than one-quarter to one-third of

the total root length.

3. *Three roots:* Length defined as in grade 2.

Upper Molar Root Number

1. *One root:* Tip may be bifurcated with deeply inset developmental grooves .
2. *Two roots:* Separate roots are greater than one-quarter to one-third of the total root length. Length determination should take into account bending which is common on third molars.
3. *Three roots:* Length defined as in grade 2.
4. *Four roots:* Length defined as in grade 2.

Radical Number

1. *One radical:* No developmental grooves.
2. *Two radicals:* Two developmental grooves or two round roots with no developmental grooves.
3. *Three radicals:* Three developmental grooves or one round root with no developmental grooves and one root with two developmental grooves.
4. *Four radicals:* Continuation of above with various root number and developmental groove combinations.
5. *Five radicals:* Continuation of above.

6. *Six radicals:* Continuation of above.
7. *Seven radicals:* Continuation of above.
8. *Eight radicals:* Continuation of above.

Peg-Shaped Incisor

0. Normal sized incisor.
1. Incisor reduced in size, but having normal crown form.
2. Peg-shaped incisor as defined above.

Peg-shaped Molar

0. Full-sized crown with normal third molar morphology.
1. Molar reduced in size to 7- to 10-mm buccolingual diameter. Form is near normal or somewhat "shriveled."
2. Molar is <7 mm in buccolingual diameter. Crown is peg or cone-shaped with rarely more than two rounded cusps lacking any secondary morphology. Root is simple and single.

Odontome

A. Odontome not present.
B. Odontome present.

Congenital Absence

0. Tooth is present. Any degree of visible impaction is considered as present.
1. Tooth is congenitally absent. No sign of tooth.

Mandibular Features

Premolar Lingual Cusp Variation

A. *No lingual cusp:* A ridge may be present that suggests a much reduced structure without a free tip, but it is scored as cusp absent. Grade A was added after plaque production began when it was realized that lingual cusps can be absent.
0. *One lingual cusp:* Size and form may vary a great deal but tip can be seen.
1. *One or two lingual cusps:* This indecisive class should not be used for worn teeth. It is better to score such teeth as missing data.
2. *Two lingual cusps:* Mesial cusp is much larger than distal cusp.
3. 3 *. Two lingual cusps:* Mesial cusp is larger than distal cusp.
4. *Two lingual cusps:* Mesial and distal cusps are equal in size.
5. *Two lingual cusps:* Dislal cusp is larger than mesial cusp.
6. *Two lingual cusps:* Distal cusp is much larger than mesial cusp.
7. *Two lingual cusps:* Dislal cusp is very much larger than mesial cusp. With wear, this class can be confused with grade O. When in doubt, score individual as missing data.

8. *Three lingual cusps:* Each is about the same size.
9. *Three lingual cusps:* Mesial cusp is much larger than medial and/or distal cusp. With wear, grade 9 can be confused with grade 3. When in doubt, score individual as missing data.

Anterior Fovea

0. Anterior fovea is absent. The sulcus between cusps 1 and 2 continues without interruption from the center of the occlusal surface to the mesial border.
1. A weak ridge connects the mesial aspects of cusps 1 and 2 producing a faint groove.
2. The connecting ridge is larger and the resulting groove deeper than in grade 1.
3. Groove is longer than in grade 2.
4. Groove is very long and mesial ridge is robust.

Groove Pattern

Y. Cusps 2 and 3 are in contact.

+. Cusps 1-4 are in contact.

X. Cusps 1 and 4 are in contact.

Cusp Number

4. Cusps 1-4 (1, protoconid; 2, metaconid; 3, hypoconid, 4, entoconid) present.
5. Cusp 5 (hypoconulid) is also present.
6. Cusp 6 (entoconulid) is also present .

Deflecting Wrinkle

0. Deflecting wrinkle is absent. Medial ridge of cusp 2 is straight.
1. Cusp 2 medial ridge is straight, but shows a midpoint constriction.
2. Medial ridge is deflected distally, but does not make contact with cusp 4 .
3. Medial ridge is deflected distally forming an L-shaped ridge. The medial ridge contacts cusp 4.

Distal Trigonid Crest

1. *Absent:* Distal borders of cusps I and 2 are not connected by a crest or loph .
2. *Present:* Distal borders are connected by a ridge.

Protostylid

0. No expression of any sort. Buccal surface is smooth.
1 A pit occurs in the buccal groove .
2. Buccal groove is curved distally .

3. A faint secondary groove extends mesially from the buccal groove.
4. Secondary groove is slightly more pronounced.
5. Secondary groove is stronger and can be easily seen.
6. Secondary groove extends across most of the buccal surface of cusp 1. This is considered a weak or small cusp.
7. A cusp with a free apex occurs.

Cusp 5

0. No occurrence of cusp 5. The molar has only 4 cusps (cusps 1-4).
1. Cusp 5 is present and very small.
2. Cusp 5 is small.
3. Cusp 5 is medium-sized.
4. Cusp 5 is large.
5. Cusp 5 is very large.

Cusp 6

0. Cusp 6 is absent.
1. Cusp 6 is much smaller than cusp 5.
2. Cusp 6 is smaller than cusp 5.
3. Cusp 6 is equal in size to cusp 5.
4. Cusp 6 is larger than cusp 5.

5. Cusp 6 is much larger than cusp 5.

Cusp 7

1. No occurrence of cusp 7.
2. Faint cusp is present. Two weak lingual grooves are present instead of one.

1A. A faint lipless cusp 7 occurs displaced on the lingual surface of cusp 2.

2. Cusp 7 is small.
3. Cusp 7 is medium sized.
4. Cusp 7 is large.

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Canine Root Number

1. One root.
2. Two roots, free for more than one-quarter to one-third of the total lingual root length.

Tomes's Root

0. Developmental grooving is absent or, if present, shallow with rounded rather than V shaped indentation.
1. Developmental groove is present and has a shallow V-shaped cross-section.
2. Developmental groove is present and has a moderately deep V -shaped cross-section.
3. Developmental groove is present, V shaped, and deep. Groove extends at

least one-third of the total root length.

4. Developmental grooving is deeply invaginated on both the mesial and distal borders .
5. Two free roots are present. They are separate for at least one-fourth to one-third of the total root length.

Lower Molar Root Number

1. *One root:* Root tip may be bifurcated. If tips are free for more than one-fourth to one-third of the total root length, score as two roots. The first molar root will usually be U-shaped in cross section with a deep developmental groove in the lingual surface . In the second and third molar roots, a single deep lingual, or deep lingual and buccal developmental grooves can occur.
2. *Two roots:* Two separate roots exist for at least one-forth to one-third of the total root length . A strong distolingual radical is likely an unattached supernumerary third root.
3. *Three roots:* A third (supernumerary) root is present on the distolingual aspect. It may be very small but is usually about one-third the size of the normal distal root.

Torsomolar Angle

Lay a small transparent protractor on the lower third molar and measure its rotation relative to a baseline fonned from the middle of the first and second molars. Without rotation, the angle is 0 degrees . If rotation is present, record it by degree, tooth, and direction (buccal or lingual). Torsomolar angle should not be measured when a tooth is impacted, or if there has been possible positional shift (mesial drift) due to antemortem loss of the first or second molar.

Other Features

Palatine Torus

0. *Torus is absent:* Palate is smooth .
1. *Trace:* Torus is elevated about 1-2 mm.
2. *Medium:* Torus is more extensive, elevated 2-5 mm.
3. *Marked:* Torus is elevated more than 5 mm.
4. *Very marked:* Torus may be 10 mm high and 10-20 mm wide. This degree of development is seldom encountered outside of Arctic populations, and even there it is rare.

Mandibular Torus

0. *Absent:* No elevation can be palpated.
1. *Trace:* An elevation can be palpated but not easily seen.
2. *Medium:* Elevation is 2-5 mm.

3. *Marked:* Elevation is >5 mm.

Rocker Jaw

0. *Absent:* Lower jaw does not rock back and forth when set on a flat surface because the projections formed by the chin and distal borders of the ascending rami from a tripod.
1. *Almost rocker:* The lower border of the horizontal ramus is sufficiently curved to make the jaw unstable when placed on a flat surface. Such a mandible will rock for about 1 sec.
2. *Rocker:* Horizontal ramus is so convexly curved that the mandible will rock back and forth on a flat surface for several seconds.

All teeth

Tooth Status

0. No wear. This occurs only in un-erupted or erupting teeth.

0-1. Wear facets can be seen with a 10x hand lens on one or more occlusal planes.

1. Dentin is exposed on one or more cusps. Almost always occurs earlier in incisors than in post incisor teeth.
2. Cusps worn off. Incisors are graded as 2 if most of the crown mass is gone.
3. Exposed pulp. Incisor crowns usually worn off.
4. Root stump is functional. All or most of the enamel is worn off.

Other notations used if wear status cannot be scored:

A. *Antemortem loss:* Socket is partly or fully filled in.

C. *Congenital absence:* This indicator is never used for subadults, as defined by third molar eruption or basisphenoid suture closure. A congenital absence score of I should be given for those teeth in which that feature is recorded.

I. *Impacted:* Usually third molars or second premolars.

P. *Postmortem loss:* Socket is open and smooth and shows no sign of filling or resorption.

U. *Unerupted:* Tooth is present but unerupted.

-. Missing data. Site not available for scoring.

Caries

Caries are scored by location on a tooth with nine possible sites: Occlusal (Oc), mesial (M) , distal (D), buccal (B), lingual (L), and combinations of occlusal and the other four surfaces, i.e ., mesio-occlusal (MO). All carious sites on a tooth are recorded.

Abscessing and Periodontal Disease

None: No identifiable bone loss. Alveolar tooth border is hard and smooth. Root exposure does not exceed 1-3 mm dependent on age. Note that supereruption can occur with as much as one-third of the entire root length being exposed without any indication of alveolar bone loss, necrosis, or pocketing.

Pockets. One to three teeth may have localized alveolar bone loss. Pockets vary in size. Remainder of alveolar bone is smooth. Record affected teeth.

Generalized slight: Periodontal disease affects many teeth with 3-5 mm of exposed root plus possible alveolar border pitting. Pockets usually occur as well.

Generalized medium: There is 4-5 mm of root exposure, alveolar border is usually ragged, and deep pockets can occur.

Generalized marked: More than 50% of the rootis exposed in many teeth. Alveolar border is severely eroded. Pocket depth and form easily grade into the appearance of an abscess. Because bone loss is usually not uniform, generalized amount is estimated on an average state of one or both jaws.

Cultural Treatment

A. *Tooth removal or ablation:* Seldom found in individuals less than 12 years of age. Ablation can be certain if gaps occur or if there is strong differential wear in opposing upper or lower teeth . To be certain that ablation and not trauma is the cause of missing teeth, a population pattern must exist.

B. *Filing:* Teeth may be filed to a point, have their labial surface filed flat or depressed, or be decorated with incised lines. Filed or chipped notches at the tooth corners may occur along with other treatment.

C. *Staining:* In betel-chewing regions of eastern Asia and the Pacific, crania are frequently encountered with red-brown stained teeth. This is unintentional treatment, whereas intentionally black-stained teeth are found in the same region.Use of tobacco stains teeth; but it is black-brown in color.

D. *Inlaying:* Cup-shaped holes can be drilled into the enamel of an incisors labial surface followed by the insertion of various decorative materials like gold, pyrite, or turquoise.

E. *Cleaning striations:* Abrasives like pumice mixed with charcoal will scratch enamel. Such cleaning or brushing striations can easily be seen on labial and buccal surfaces with a 10x hand lens. Excessive brushing can leave notches on buccal surfaces, usually at the crown-root junction. Toothpick grooves can be found on buccal surfaces, but more often on distal or mesial root surfaces at or near the crown-root junction.

Crown Chipping

Exfoliation or pressure chips are indicative of various tooth use activities (furner and Cadien, 1969). When less than ten teeth are chipped, each is scored.

If chipping is present on the majority of teeth regardless of number, it is identified as generalized. Minor flaking of marginal enamel in teeth with grade 2 or 3 wear is not considered as crown chipping.

Other Treatment

0. *No damage:* TMJ surface is smooth and unpitted.
1. *Slight:* One-fourth of the TMJ surface is pitted.
2. *Medium:* More than one-fourth but less than one-half of the TMJ surface is pitied, sometimes deeply so, and sometimes with raised borders.
3. *Severe:* More than one-half of the TMJ area is pitted, eroded, and raised borders may be substantial. Eburnation may be present.