Ailments of the Abbey: Toward an Enhanced Understanding of Individual Paleopathological Cases

by

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Abstract

In the summer of 2016, archaeological excavation by the Wesleyan-Brown MonArch team unearthed the skeletal remains of three individuals at two separate medieval monasteries in Northern France. Without a population to study, what paleopathological conclusions could be drawn about these three people? This thesis addresses this question in multiple ways. First, histories of paleopathology and archaeological theory are explored. Then, common paleopathologies of medieval Europe are discussed, the excavation is described, and the skeletal remains are analyzed. Finally, a new hybridized theoretical approach is proposed to interpret the three excavated individuals. Inspired by phenomenology, this new framework combines differential diagnoses, information from extant medical texts, and the idea of a shared human experience to understand the human disease experience in medieval Europe.
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# Table of Contents

List of Figures ......................................................... vi
List of Tables ......................................................... viii
Introduction .......................................................... 1

## Chapter One: An Introduction to Paleopathology

- Introduction ......................................................... 5
- The history of paleopathology ...................................... 5
- Current and future paleopathological methods and theory .......... 13
- Methodological challenges of paleopathology ..................... 19

## Chapter Two: Medieval Paleopathology

- Methods of paleopathology .......................................... 24

### Dental disease

- Introduction ......................................................... 26
- Basic dental anatomy ................................................. 27
- Common dental pathologies of the European Middle Ages .......... 28
- Attrition .............................................................. 29
- Antemortem tooth loss .............................................. 31
- Dental enamel hypoplasia ............................................ 31
- Dental calculus ....................................................... 32
- Caries ................................................................. 33
- Dental abscess ....................................................... 35
- Periodontal disease ................................................. 36

#### Case studies

- Medieval Britain .................................................... 37
- Medieval France ..................................................... 38
- Medieval Serbia ..................................................... 40

### Joint disease

- Introduction ......................................................... 42
- Basic joint anatomy ................................................ 43
- Common joint diseases of the European Middle Ages
  - Osteoarthritis ..................................................... 45
  - Erosive osteoarthritis ......................................... 47
  - Osteoarthritis and occupation ................................ 48
- Spinal joint disease ............................................... 49
- Rheumatoid arthritis .............................................. 50
- Diffuse idiopathic skeletal hyperostosis .......................... 52

#### Case studies

- ................................................................. 54
### Infectious disease

- Introduction .................................................. 60
- Non-specific bacterial infections .......................... 60
- Tuberculosis .................................................. 62
- Leprosy .......................................................... 67
- The Black Plague ................................................ 69

### Chapter Three: Ailments of the Abbey

**Methods of bioarchaeology** .................................. 74
- Biological sex estimation .................................... 75
- Age-at-death estimation ...................................... 77
- Stature estimation .............................................. 80

**Bourgfontaine**
- Introduction to Bourgfontaine .............................. 81
- I. Trench 12: Cimetière ....................................... 82
- II. Methods of excavation from discovery to removal .... 82
- III. Analysis of the burial space ............................ 86
- IV. Skeletal analysis ........................................... 88
- V. Paleopathological analysis ............................... 96

**Preuilly Abbey**
- Introduction to Preuilly Abbey .............................. 104
- I. Chapter room burial ....................................... 104
- II. Methods of excavation from discovery to removal .... 106
- III. Analysis of the burial space ............................ 107
- IV. Skeletal analysis ........................................... 112
- V. Paleopathological analysis ............................... 115

### Chapter Four: Paleopathological Interpretations

- A departure from “science” .................................... 119
- An overview of medieval medicine ........................... 124
- Peter the Venerable ............................................. 126
- An inferred reality of medieval dental pathology .......... 128
- Stigmatized disease ............................................ 132
- Concluding thoughts .......................................... 134

### Photo and Illustration Credits
- ................................................................. 135

### Bibliography
- ................................................................. 136
List of Figures

Figure 2.1 Cross section of a tooth 28
Figure 2.2 Diagram of a synovial joint 44
Figure 3.1 17th century painting of Bourgfontaine 82
Figure 3.2 Beginning stages of Bourgfontaine burial excavation 84
Figure 3.3 Overhead view of Bourgfontaine burial 85
Figure 3.4 Hand placement of BF-16-1 85
Figure 3.5 Hook and eye metal fastener from Bourgfontaine burial 85
Figure 3.6 Excavated burial cut of Bourgfontaine burial 86
Figure 3.7 Indentation on the right os coxa of BF-16-2 88
Figure 3.8 Indentation on the left femoral neck of BF-16-2 88
Figure 3.9 Diagonal slice through vertebral body of BF-16-2 88
Figure 3.10 Right os coxa of BF-16-1 92
Figure 3.11 Left os coxa of BF-16-1 92
Figure 3.12 Right os coxa of BF-16-2 92
Figure 3.13 Remodeling alveoli in mandible of BF-16-1 96
Figure 3.14 Extreme calculus accumulation on left M1 and M2 of BF-16-1 98
Figure 3.15 Receding alveolar structures on the maxillae of BF-16-1 98
Figure 3.16 Osteophytes on sternal end of first rib of BF-16-1 100
Figure 3.17 Woven bone on the sternoclavicular joint surfaces of BF-16-1 100
Figure 3.18 Periosteal reaction on both humeri of BF-16-1 100
Figure 3.19 Healing lesion on distal tibia of BF-16-1 100
Figure 3.20 Mandibular resorption on BF-16-2 103
Figure 3.21 Remodeling alveolus on mandible of BF-16-2 103
Figure 3.22 Osteophyte on anterior vertebral body of BF-16-2 103
Figure 3.23 Unilateral bone reaction on left tibia of BF-16-2 103
Figure 3.24 Plan of Trench SC-2016 in the chapter room at Preuilly Abbey 105
Figure 3.25 Overhead view of Burial 1 at Preuilly Abbey 108
Figure 3.26 Excavated burial cut of Burial 1 at Preuilly Abbey 108
Figure 3.27 Illustration of Burial 1 108
Figure 3.28 Abscesses on the maxillae of PA-16-1 116
Figure 3.29 Abscess on the canine jugum of PA-16-1 116
Figure 3.30 Varied patterns of wear on the upper dentition of PA-16-1 116
Figure 3.31 Mandible of PA-16-1 117
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.32</td>
<td>Healing lesion on left fibula of PA-16-1</td>
<td>118</td>
</tr>
<tr>
<td>4.1</td>
<td>Mandibular resorption of BF-16-1, BF-16-2, and PA-16-1</td>
<td>131</td>
</tr>
</tbody>
</table>
List of Tables

Table 1 Sex estimation of BF-16-1 ........................................ 89
Table 2 Sex estimation of BF-16-1 (cont’d) .......................... 89
Table 3 Age-at-death estimation of BF-16-1 ......................... 91
Table 4 Sex estimation of BF-16-2 ........................................ 93
Table 5 Sex estimation of BF-16-2 (cont’d) .......................... 93
Table 6 Age-at-death estimation of BF-16-2 ......................... 95
Table 7 Age-at-death estimation of PA-16-1 ......................... 113
Table 8 Stature estimation of PA-16-1 ................................. 114
Table 9 Age at death estimation of PA-16-1 ......................... 114
Introduction

Science had never limited my quest for knowledge before. As a biology major, I have been a firm believer that the best way to solve a problem is to apply the scientific method. Whenever my questions pushed the boundaries of biology, I found explanations in chemistry; whenever I questioned chemistry, I turned to physics. For me, science has always felt objective and safe. It made sense, then, that as I began my pursuit of a dual major in archaeology, I was naturally drawn to osteology. Back then, I considered the body, and therefore the skeleton, strictly scientific—built, regulated, and even decomposed through genetic expression and cell-to-cell interactions—and through its exploitation, bioarchaeologists were able to collect what appeared to be boundless amounts of information. Osteological methods seemed foolproof and thorough, producing data that supported conclusions about demographic structure, past diet, and prevalence of pathologies. Two years ago, I believed that studying individuals from the past through the analysis of their skeletal remains would allow me to approach archaeology the same comfortable way I had approached biology. It would take a variety of field experiences across three different continents to make me realize the limitations of this kind of strictly objective thought.

I immersed myself in the study of archaeological human remains for the first time when I attended Arizona State University’s Bioarchaeology and Human Osteology Field School in K cambsville, Illinois, during the summer of 2015. While there, I learned the techniques for fragmentary bone analysis, sex estimation, age-at-
death estimation, biodistance analysis, stature estimation, and paleopathological examination. The Center for American Archeology in Kampsville provides osteology students with a comprehensive skeletal collection for study, excavated from the burial mounds of Native Americans from the lower Illinois River Valley. Using this thoroughly catalogued collection, I was able to compare the data I collected from the skeletons to data from previous studies—and then correct my findings accordingly. By the end of the six-week program, I was familiar with the lab techniques of bioarchaeology and eager to test my new skillset in the field.

A few months later, I left Wesleyan for a semester abroad at the Turkana Basin Institute (TBI) in Kenya, excited about applying what I had learned in Kampsville to fossil identification. However, in the field at TBI, there were rarely human skeletal remains to examine. Instead, fragmented bones of prehistoric mammals and fish covered the desert sand. What I knew about the human skeleton helped me identify the animal fossils, but it wasn’t until the human dispersals portion of the field school in Kenya that I was back in my element. I was captivated by a project involving 10,000-year-old skeletal remains, during which I was asked to draw conclusions about a single bone from multiple individuals in a population. Given a shelf full of partially fossilized femurs, I worked to identify the variation in the size and shape of the linea aspera (a vertical ridge on the posterior femur where many muscles of the lower limb attach). I was grateful for the technical lab training and statistical methods I had learned in Kampsvill, but I still desperately wanted to work on an excavation of human remains.

Incredibly, while I was studying in Kenya, I was offered the opportunity of a lifetime—the chance to excavate human burials under the direction of Wesleyan
University’s Clark Maines and Brown University’s Sheila Bonde. Professor Maines told me that the MonArch team was returning to Northern France to continue work on the excavation of Bourgfontaine monastery, and that he was hopeful, but unsure, that burials would be found. By the end of June, all that uncertainty was put to rest as physical anthropologist Emma Maines and I had excavated not one, but two, nearly complete skeletons (BF-16-1 and BF-16-2). After the six-week excavation of Bourgfontaine came to a close, we traveled to Preuilly Abbey, France, where we would excavate for the next two weeks. The first few days were discouraging; we unearthed very little material culture and no evidence of human burial. However, we were fortunate once again, finding a secondary burial within the bounds of our trench (PA-16-1). Although my training in osteology proved useful at both Bourgfontaine and Preuilly Abbey, the experience of excavating human burials revealed an entirely new side of bioarchaeology to me. Excavation felt more personal and intimate than lab analysis alone.

Returning to Wesleyan, I knew I wanted to write my thesis about the skeletal remains I had excavated in France, but once I finally decided on the topic of medieval paleopathology, I ran into a significant roadblock. The techniques I had learned in Kamps ville and at TBI were useful for large skeletal samples—but not for the small sample sizes I had excavated at the monasteries. Without access to population-wide data, what, if any, conclusions could I draw? What could these few individuals tell me about the human disease experience in medieval Europe? For the first time (ever), I decided to leave “science” behind me and take a more hybridized theoretical approach to my paleopathology problem.
Through an exploration of the history of both paleopathology and archaeological theory, I learned that others have encountered similar challenges when applying a strictly scientific approach to bioarchaeology. Not only can bioarchaeology methods be limiting; they can also lead to a “loss of the individual” in the mass of population-wide studies. Chapter One highlights these issues in the context of the history of the discipline. Chapter Two investigates the common paleopathologies of the Middle Ages, which frame the paleopathological analyses described in Chapter Three. Chapter Four discusses the culmination of the three prior chapters and addresses the various options for individualistic paleopathological studies.
Chapter One: An Introduction to Paleopathology

“[D]isease is a form of altered life and therefore is probably as old as life itself.”

Rudolf Virchow (Aufderheide and Rodríguez-Martín 1998:4)

Introduction

When addressing the progression of the field of paleopathology through time, there are three paths to follow: the history of paleopathology itself, the history of bioarchaeology, and the history of archaeological thought and theory. The theoretical frameworks used in archaeology have developed over time, often impacted by the same stimuli that have changed the fields the paleopathology and bioarchaeology. Simply, theory is a guiding thought process that influences an archaeologist’s research questions and the interpretation of their data. However, what qualifies as “theory” is debated—to some archaeologists theory is all frameworks of thought, while to others, theory is specifically interpretations influenced by ideological thought. The focus in the following section is the history of paleopathology, however, since they follow similar trajectories, the paths of archaeological thought and bioarchaeology are included for contextualization.

History of paleopathology

Within the last few centuries, paleopathology has been guided and shaped by the fields of anthropology, archaeology, and medicine (Ortner 1991: 5). These three disciplines approach past human disease and its manifestation in the human skeleton from different angles. Most obviously, archaeology focuses on material from the past while medicine
on material from the present, but together they have induced the growth of an interdisciplinary field anchored in science and influenced by archaeological theory. The Cambridge Encyclopedia of Human Paleopathology (1998) divides the field’s history into four phases: “Antecedent phase” (Renaissance to mid-nineteenth century), “Genesis of Paleopathology” (mid-nineteenth century to World War I), “Interbellum Consolidation phase” (1913-1945), “New Paleopathology phase” (1946 to present) (Aufderheide and Rodríguez-Martín 1998: 1).

In the sixteenth century, when the first “paleopathological” inquiries were made, very little was known about the agents of disease and how disease may alter a healthy human skeleton. In fact, during this Antecedent phase, most of the research involving ancient disease was devoted to the study of diseases of prehistoric animals. This focus resulted in incorrect, and oftentimes misleading, conclusions, such as the misidentification of animal bones as human malformations. An extreme example of this is Felix Platter’s misidentification of elephant bones as human gigantism (Aufderheide and Rodríguez-Martín 1998: 2). However, not all studies resulted in fallacies. Some paleopathologists pinpoint the true founding of the discipline to the late eighteenth century, when Johann Friederich Esper correctly diagnosed osteosarcoma in a cave bear femur (Aufderheide and Rodríguez-Martín 1998: 2). Whether or not the conclusions were correct, publications at this time were exclusively anatomical, describing the abnormalities in the skeleton at hand in contrast to what was thought to be normal. The focus on description and identification deterred exploration into the causes of osteological change (Ortner 2003: 8). As a result, the discipline was slow to change.
The nineteenth century saw great advances in the field of medicine, for example Robert Koch’s postulates which linked specific microorganisms to specific diseases (also called germ theory of disease) (Madigan et al. 2009: 14-15). In effect, though still deemed the Antecedent phase, a few noted anthropologists and physicians at this time began to recognize the importance of studying the history of human disease. One of these pioneers was Phillip Franz bon Walther, who in 1825 pondered disease origins and speculated that genetic inheritance may be a major factor. The introduction of microscopy into the field of paleopathology facilitated the exploration of unknown physiological characteristics of the human body. For instance, between 1833 and 1843 Louis Agassiz used microscopy to determine the microstructure of teeth. Despite the slow progress made throughout this phase, the Antecedent phase is defined as a period of “isolated observations of a descriptive nature carried out mostly with little scientific precision and on specimens viewed primarily as curiosities, not as sources of medical, pathological or historical knowledge” (Aufderheide and Rodriguez-Martín 1998: 3).

During the Genesis of Paleopathology, the period from the mid-nineteenth century to World War I, the field remained anthropologically focused, however two progressions occurred that would change the discipline forever. The first was the increased interest in the field of archaeology, which provided those studying paleopathology with large collections of excavated human and animal bones kept in museums and universities (Aufderheide and Rodriguez-Martín 1998: 4). Although mainly utilized by physical anthropologists with what we would see now as a racist agenda (seeking to determine the origins of human races), anthropologists and physicians interested in ancient disease also greatly benefited from the wealth of these
collections. For example, it was during the Genesis of Paleopathology that the origin of syphilis, a disease that causes significant osteological modifications, was first explored. These studies sparked heated academic debates (which continued for the entirety of the twentieth century) and marked the first time paleopathological analysis was used to understand a biological problem (Ortner 2003: 8). The second advancement during the Genesis of Paleopathology was the invention of radiography in 1895 by German physicist Wilhelm Conrad Röntgen. X-ray technology allowed physicians and anthropologists to examine the skeleton in living individuals, expanding anatomical knowledge. As a result, precision of paleopathological studies improved and better methods were created. With these progressions, researchers in certain locations excelled and a handful stood out among the rest as leaders in paleopathology. For example, paleopathology in France flourished. French anthropologists identified cranial trepanations as antemortem surgeries in different indigenous populations around the world. The United States also carried out noteworthy research, such as the identification of treponemal lesions from bones in Kentucky and Tennessee described by Joseph Jones. Case studies like these, and an overall increased dedication to the field, led to the establishment of three formalized institutions with osteological collections: The U.S. Army Medical Museum (1862), the National Museum of Natural History, and the Museé de L’Homme (Aufderheide and Rodríguez-Martín 1998: 5).

The methodology of paleopathology improved further in the Interbellum Consolidation phase, with the introduction of statistics and the further application of radiography, histology, and serology. It was during this phase, with the consolidation of previous observations and the partial standardization of methods, that
paleopathology rose as a scientific discipline. Many of the “standardized methods” were developed through analysis of this period’s defining focus—mummy pathology. The leader in the Egyptian mummy subfield, and one of the researchers who helped establish paleopathology as a “distinct focus of scientific research,” was Sir Marc Armand Ruffer (Ortner 1991: 5). Through the application of his medical knowledge and techniques, Ruffer identified diseases such as schistosome ova, atherosclerosis, osteoarthritis, congenital conditions, malaria, and tuberculosis in ancient humans. Beyond his accurate diagnoses of past diseases, Ruffer’s publications were also shaped by an awareness of the epidemiological implications of his conclusions—an important step towards the eventual shift away from antiquarianism in both the fields of paleopathology and archaeology. After his death in 1917, paleopathology returned to its original focus of human skeletal analysis, but with new methods. For example, paleopathologists began to use radiography on dry skeletal remains, resulting in more precise analysis of rheumatic diseases, hip dislocations, and dental paleopathology.

Before World War II, archaeology also had a restricted outlook, and the status of archaeological theory during this period is debated. Certain archaeologists view this period as atheoretical, arguing that past archaeologists succeeded in amassing collections of artifacts but made few useful interpretations with applied theoretical frameworks after excavation. Others archaeologists would argue that “theory is omnipresent,” and even if theoretical approaches were not explicitly discussed, they were present and shaping the conclusions being made (Hegmon 2003: 233). Like paleopathology, archaeology before the mid-twentieth century was centered around collections and classifications, however there was also a focus on chronology (Willey
and Sabloff 1993: 96). This period in archaeological history is often referred to as “cultural-historical,” because artifacts were grouped into types representing “cultures,” and conclusions were often threaded through historical narratives (Johnson 2010: 18). The concept of “culture” arose in Europe from the late nineteenth century revelation that culture varied geographically, and through a fascination with ethnicity stemming from growing nationalism and racism (Trigger 2006: 211). Johnson (2010: 17) labels this thought process as normative, stating that it assumes both that “artefacts are expressions of cultural norms” and that these “norms define what ‘culture’ is.” Johnson also notes the potential binds of this theoretical approach, such as the tendency to “particularize,” focusing on the minute differences between cultures instead of the vast similarities (Johnson 2010: 18). In this mindset, cultures may also appear static and unchanging. The active participants in cultural change are ideas “diffusing” from one human group to another instead of human growth and change within a population (Johnson 2010: 19). Although the cultural-historical approach is older than other theoretical frameworks, it continues to shape archaeologists’ conclusions. Despite its consequences, archaeologists find value in the theoretical framework’s “ability to trace real lineages of the development of material culture in the archaeological record” (Trigger 2006: 313). Current historical archaeology projects are often approached with cultural-historical theory because it emphasizes description and conclusions can be drawn from documented sources (which are unavailable to studies of prehistoric archaeology) (Johnson 2010).

After World War II, both paleopathology and archaeology shifted toward science and data oriented approaches. The New Paleopathology phase is marked by
movement away from individual case studies to cemetery- and population-wide studies. This change led to the full incorporation of epidemiology and demography into the field—both are studies that can only be performed on large sample sizes. Furthermore, in the latter half of the twentieth century both clinical and laboratory medicine were consistently developing new and better techniques which promoted more accurate diagnoses in both living and archaeological specimens (Aufderheide and Rodríguez-Martín 1998: 7-10).

The shift toward science in archaeology was accompanied by a reevaluation of interpretive methods. Although there was a vast accumulation of archaeological material, some archaeologists were dissatisfied because it did not result in much progression in the field. These archaeologists banded behind a “New Archaeology” approach, declaring the discipline needed to be “more scientific and more anthropological” (Johnson 2010: 21). The collections and descriptions of artifacts were of value, but archaeologists wanted to move beyond the question “what is it?” and ask “what does it mean?” To answer this question, the “scientific” approach seemed promising because, as Johnson states, “science progresses: it does not simply collate its facts into orderly patterns, rather it confronts theory and data in such a way as to make larger and larger and deeper and deeper its understanding of the world” (Johnson 2010: 22). Challenges in adopting this approach included facing personal biases head on, as well as shifting focus to all aspects of a society and understanding the importance in variability. New sampling techniques and theory tackled these challenges, creating better representative samples of sites for study. This approach also melded well with the applicable scientific advances of the time. Beyond the emphasis on science, New
Archaeology was rooted in progressive ideas about the way culture functions and changes throughout time. Culture was no longer a representation of societal norms, but rather a form of adaptation to the environment. When viewed as an adaptation, culture became much less random and more systematic, growing and changing in a form of cultural evolution. New archaeologists (or processual archaeologists) also viewed culture as a process, one that has existed throughout time and irreversibly changes based on underlying principles (Johnson 2010: 74-75). The external means of cultural exchange proposed by cultural-historical archaeologists became inverted by processual archaeologists who focused on the internal social and cultural changes within a society (Trigger 2006: 386).

Funerary archaeology was also a topic of discussion during this time. The work of Lewis Binford (1971) and Arthur Saxe (1970) provided overarching frameworks for the biological and sociocultural interpretation of mortuary archaeology. Along the lines of other processualist ideas, Binford argued that mortuary customs were not random, but dependent on cultural systems with “form and structure” (Binford 1971: 23). Saxe mainly elaborates on Binford’s conclusions. This framework governed the archaeology of death in the United States for two decades before it eventually became the object of critique during the next progressive wave of archaeological theory.

A few years after these publications, the field of bioarchaeology surfaced in the United States. Defined first as a multidisciplinary approach to answer the questions of social organization, geography of genetic pools, diet, population density, health, and levels of interpersonal violence using both science and archaeology by Buikstra (1977), the field soon shifted further in the direction of science. More recently,
bioarchaeologists like Larsen (2002) explore human skeletal remains through the utilization of disciplines other than archaeology, such as chemistry and geology (Charles 2013: 17). Other bioarchaeologists note the field’s reliance on science, saying it “has returned to a more explicit physical or biological anthropology” (Charles 2013: 17). With the incorporation of the newest technology and methods, scientifically focused bioarchaeology can yield exciting conclusions, such as specificities of past diet. However, some bioarchaeologists view the absence of “true” archaeology as a problem that needed fixing through the incorporation of post-processual theory and even more recent theoretical frameworks.

**Current and future paleopathological methods and theory**

Throughout the histories of archaeology, bioarchaeology, and paleopathology, research transitioned from trying to answer the question “what is it?” to querying the additional “what does it mean?” (Ortner 1991: 5). This question was explored scientifically during the processual phase, but not without critiques. For example, some archaeologists felt this theoretical approach lacked the human touch, overlooking the individual and the power of human action.

During the 1980s, a new theoretical movement, called post-processualism, swept through archaeology. Where the New archaeology theoretical frameworks discussed above promoted scientific approaches, post-processual archaeology emphasized interpretation and history (Hegmon 2003). Johnson (2010: 105-110) summarizes the concerns of proponents of the post-processual movement in eight key statements:
1. We reject a positivist view of science and the theory/data split. The data are always theory-laden.

2. Interpretation is always hermeneutic.

3. We reject the opposition between material and ideal.

4. We need to look at thoughts and values in the past.

5. The individual is active.

6. Material culture is like a text.

7. We have to look at context.

8. The meanings we produce are always in the political present, and always have political resonance. Interpreting the past is always a political act.

From these major ideas branched other concepts and frameworks (e.g. Feminist perspectives) with which to interpret archaeological material. For instance, the concept of agency, a term referring to the “active strategies of individuals,” brought archaeological conclusions to life (Johnson 2010: 108). The idea of agency becomes relevant for paleopathology because it relates to the individual. Here, tension is found between what is thought to change the body and what is actually changing the body throughout life. Skeletal changes may be caused by the external environment, such as pathogens or cultural practices (i.e. wearing shoes which causing changes in the foot bones), yet humans have agency to act and through those actions may control the effects on their bones.

Without the specific focus on the individual, how can other post-processual frameworks be applied to the skeletal remains that are analyzed in the fields of bioarchaeology and paleopathology? Osteoarchaeologists like Sofaer (2006) wished to
answer this questions through reuniting “osteology and archaeology, not as a collaborative enterprise in Buikstra’s sense but as a synthetic ‘theoretical osteoarchaeology’” (Charles 2013: 17). While much of archaeology today can be discussed in terms of theory, bioarchaeology and paleopathology present challenges. As disciplines lying somewhere between archaeology and medicine, where does theory fit in? And is theory necessary? Sofaer tackles these questions, while also critiquing current osteoarchaeologists for their stagnant stance on theoretical interpretation:

Above all, the most serious fracture lies between notions of the biophysical body and the culturally constructed body. Both New Archaeology and post-processual archaeology, while relying on the body and trusting in science, failed to develop theoretical insights in their analyses. (Sofaer 2006: 25).

The field of bioarchaeology is guided, and potentially restricted, by the application of scientific methods used for age and sex estimation, resulting in the categorization of skeletal material, typically only interpreted through their association with artifacts. Sofaer explains that even when human remains are approached with post-processual theory, the physicality of the skeleton gets in the way of purely theoretical conclusions:

Post-processualism took on the body as a powerful way of demonstrating cultural meanings by deliberately transforming it from biology to symbol or metaphor…Despite this emphasis on the social construction of the body, post-processualist approaches to interpretation still required the skeletal body as the hook on which to hang interpretations. (Sofaer 2006: 20)
Much of the tension Sofaer discusses is found between archaeological theory and the scientific method. Although modern westernized thought may identify the body as a scientific object, this is not necessarily the way people of other time and place would have defined it. Taking science and data as undeniable truth ignores the fact that science itself is a culturally constructed idea (Sofaer 2006: 26). This is unavoidable, some say science is the modern western world’s god, yet with utilization of the scientific method and replication of experiments, many scientific conclusions are in fact irrefutable. However, in bioarchaeology, many “experiments” are unrepeatable—the same skeleton cannot be dug out of its original context more than once. Other disciplines, such as astronomy and geology, face similar critiques. This caveat slightly distances bioarchaeological excavation from science and its objective nature.

Methodological approaches to post-excavation analysis also blur the hard lines of science. Based upon data collected from specific skeletal collections or from clinical studies, methods of age or sex estimation are not applicable to all variations of the human skeleton. A skeletal collection from a certain geographic location will demonstrate the variation within that population well, but will not account for the normal variation present in another population. Comparisons between populations with differing ranges of variation may lead to false conclusions. Clinical studies present issues as well. Typically observed through radiology, the bone of a living individual may not display the skeletal changes of age, sex, or disease in a way that is identical to dry bone. For example, methods for diagnosing joint disease are very different for clinical and archaeological studies. Even when population-wide studies represent the best average of a past group, they also lead to gross generalization of the natural
variation amongst humans. When creating a standardized method, a large sample size must be evaluated and ranges of variation must be noted. However, when the final product is a representation of the average skeletal features, the individual has been lost—but then these are the same methods that will be used to “reconstruct” individuals from the past.

Overall, Sofaer is dissatisfied with the dryness and rigidity of the science used to approach bioarchaeological problems. Though she acknowledges the attempts of theoretical approaches, Sofaer still views bioarchaeology as relatively atheoretical. However, this is just one perspective. Charles (2013) also notes this tension between science and theory, but finds a Darwinian versus Marxian divide responsible, not an atheoretical versus theoretical divide: “The failure to communicate related to the fact that biological anthropology is highly theorized, but it is Darwinian theory, not Marxian” (Charles 2013: 19). The goal of Darwinian archaeological theory is the application of Darwinian theory to “the archaeological record and thus to replace general concepts of cultural evolution with a more rigorous and scientific understanding of evolution,” while Marxian thought exposes ideologies in the past and in the present (Hegmon 2003: 216; Johnson 2010).

Sofaer explains two new theoretical approaches in detail—phenomenology and embodiment. Phenomenology is “the study and description of phenomena” (Johnson 2010: 117). Although applied most frequently to describe the experience of being in the presence of a monument or landscape, phenomenology also stresses the body and the sensations a body may experience (Johnson 2010). For this reason, phenomenology may be a useful approach for understanding the effects of disease on individuals from
the past. Although osteological and scientific techniques would be used for analysis, once a human skeleton has been diagnosed, a phenomenological approach may help answer further questions. For example, if an individual has clear evidence of severe osteoarthritis in both of the shoulder joints, how was that experienced during this individual’s life? Was it “normal” for people of this age to have osteoarthritis in their shoulders? Did the ailment prevent this person from doing work? What pain would this person have felt, and was there any medical care for people with pained joints? The list goes on. Documented sources may help historical archaeologist explore these questions. Ortner (2003) agrees that the way disease is interpreted must be historically contingent: “Theoretical issues include the need for greater understanding of what skeletal disease means in terms of the general morbidity that existed within the living population in which the person with skeletal disease lived” (Ortner 2003: 9). Prehistoric archaeologists, however, have little factual evidence to base claims upon. In this case, archaeologists may focus on the shared experience of sensations within the human body—under the assumption that individuals with osteoarthritis today experience similar pain and debilitations as individuals with osteoarthritis centuries ago. Yet, even archaeologists open to many theoretical approaches are critiqued: “Lack of focus on general theory contributes to open-mindedness, on the one hand, but at another level this lack of focus can also disguise the importance of theory” (Hegmon 2003: 233).

Theoretical arguments aside, there are scientific techniques (other than the methods for age and sex estimation which are based on population-wide skeletal data) which are repeatable and strictly follow the scientific method. These scientific
approaches may be reliable methods for understanding past people. For example, ancient DNA (aDNA) analysis has been used to confirm disease diagnoses and genetic comparisons of pathogens. Schuenemann et al. (2013) applied DNA capture and high-throughput DNA sequencing techniques to eleventh to fourteenth century human skeletal remains in order to isolate and analyze near complete genomes of *Mycobacterium leprae*, the bacteria that causes leprosy in humans. These scientific techniques not only confirm diagnoses for a greater understanding of the individual, they also yield answers that may help place a disease experience in time, such as the potential routes of passage. (See ‘Infectious disease’ section of Chapter Two.)

It appears there may always be this friction between theory and science, but the most interesting conclusions will come from balance between to two sides of the spectrum. This diversity in thought and approach will only push each side to do better work and allow for fuller understandings and interpretations of archaeological remains.

**Methodological challenges of paleopathology**

As discussed above, early paleopathological research approached abnormal human skeletal remains with the question “what is it?” Today, researchers ask more explorative questions like “what does it mean?” (Ortner 1991: 5). Despite the efforts to answer new questions theoretically, paleopathologists still run into trouble with the methodological approaches to answering the first question. The human skeleton offers a wealth of information on an individual’s health and collections of skeletons make even grander conclusions possible, but current methodological issues prevent the full utilization of this information.
One of the main problems noted by Ortner (2003) is the lack of consistency in the methodologies of description. For example, some paleopathologists “offer an opinion on diagnosis of paleopathological specimens without carefully describing the type and location of the lesions,” which prevents independent evaluation of the data (Ortner 1991: 8). However, even when a study does include adequate description of pathological lesions, the methods in use may not be cohesive with those of other studies rendering comparative studies invalid. For example, certain descriptive terminology may be suitable for a particular study, but if not consistent with the terminology in other case studies, it precludes further comparisons and conclusions. It is these comparisons that would allow for the calculation of disease frequencies at different places and times (Waldron 2009: 7). To improve consistency, Ortner states that paleopathology needs “a widely accepted method to describe the types of abnormal conditions that exist, using criteria that reflect the underlying pathological processes,” as well as a protocol “to show, in detail, the location of all abnormal conditions within a paleopathological case” (Ortner 1991: 8). Such methods would hopefully be less dependent on a “sophisticated knowledge of pathology and radiology,” making paleopathological analysis an accessible goal for more researchers (Ortner 1991: 10). One way methodology has been regulated is through scoring systems. For instance, for the examination of dental calculus, Brothwell developed a three-point scoring system which declare levels of build up as “slight,” “medium,” or “considerable” for both supra-gingival and sub-gingival calculus (Hillson 1996: 259). Beyond description, other variables in need of regulation for comparative studies are sample size and geographic location of the case studies in question. If case studies are from different
geographic locations and the sample size of one of the studies is small, it may misrepresent its population of origin, leading to false comparisons and conclusions. However, if they are from the same geographic location, comparisons may be made more freely.

It is also useful to compare data from archaeological studies to data from modern-day bone reports (Waldron 2009: 7). The desire to make these comparisons, however, may have led to paleopathology’s “over reliance on clinical diagnostic criteria” (Ortner 1991: 6). Although both paleopathology and medicine are fields that aim to diagnose human disease, the differences in analyzing dry skeletal remains and skeletons of living patients make comparison much less straightforward. For example, many features that would be recorded as pathological in an archaeological sample have no direct correlate in a clinical analysis, and skeletal modifications that are apparent on dry bone may not be revealed during X-ray examination of a living patient’s skeleton (Ortner 1991: 6). Comparisons are still encouraged, though, and Ortner states: “Collaboration between the paleopathologist and various medical specialists is likely to provide a more complete picture of skeletal responses to disease” (Ortner 1991: 7). However, both parties must be cognizant of the fact that they may recognize different diagnostic features of the human body in response to the same disease.

The goal of modern paleopathology is “accurate description and, where possible, diagnosis of pathological conditions encountered in archeological human remains,” but there is some question of how much focus should be placed on diagnosis (Ortner 2003: 9). A recent study of fifty-three clinical reports found that up to half of all diagnoses made by physicians are incorrect, often leading to administration of the
wrong treatment (Waldron 2009: 3-4). If this is the case for living patients, it is improbable that paleopathologists will make more accurate diagnoses without the help of visible effects to bodily systems other than the skeleton and vocalized symptoms from the patient. Still, producing a list of possible diseases, called a differential diagnosis, is common goal of paleopathologists. However, like the methodological issues with description, there is no universal system for diagnosing disease in the skeleton. To combat this issue, Waldron proposed that, in addition to thorough description, paleopathological studies should utilize a set of operational definitions for diagnosis. An operational definition is “a set of criteria that must be fulfilled in order for the disease to be recognised” (Waldron 2009: 6). Ortner agrees that the discipline needs to develop “a classificatory system for paleopathology which will take into consideration the type and detail of information that is available and can be evaluated in a paleopathological specimen,” but also notes that “describing the type and location of abnormal conditions is a far less complex problem than arriving at an accurate diagnosis” (Ortner 1991: 5,8).

Although detailed, and regulated, description remains the top priority, new methods may make accurate diagnosis a more feasible goal. Certain advancements in biology, like aDNA analysis, can confirm the diagnoses of some infectious diseases, however the diagnosis of other diseases, such as osteoarthritis, stay dependent upon morphological analysis. Even with recent progressions, there are unavoidable limitations to paleopathology. For example, if diagnostic methods were 100% accurate, it is still “generally impossible for paleopathologists to determine the cause of death of those they examine” (Waldron 2009: 1). Additionally, there are almost certainly new
diseases today that were not present in antiquity, and vice versa, not to mention the evidence that infectious diseases become less virulent with time (Ortner 1991: 11). Lastly, Waldron makes the point that even if there are no skeletal indicators of disease, it is unlikely the individual in question was healthy:

> It may very well be the case that there is little evidence of bone or joint disease in an assemblage. However, to then infer that the individuals were in good health seems perverse, given that they are all dead and that it is probable that at least a third to a half of them will have died prematurely. (Waldron 2009: 10)

Working within the bounds of these limitations, paleopathology has the potential to contribute to knowledge regarding “the biological and evolutionary role of disease in human societies,” the relationships between disease and social change throughout human history, and the “biomedical response of the skeleton to disease” (Ortner 1991: 11).
Chapter Two: Medieval Paleopathology

“The intermittent backache, the stiffness and inability to touch the toes are all too familiar features of this ageing process. Just as today, so it was in antiquity.”

(Roberts and Manchester 1995: 107)

Methods of paleopathology

Paleopathological analysis begins with a focus on skeletal irregularities. After recording any and all irregularities, paleopathologists then categorize the changes as antemortem or postmortem. Both antemortem and postmortem processes can cause bone destruction and changes in bone shape and size, however abnormal bone formation is always the result of antemortem pathological processes. Furthermore, antemortem destructive processes tend to leave smooth or rounded edges, while postmortem destructive processes result in sharp, jagged edges. After this differentiation has been made, paleopathologists address other questions, including: Was the lesion active or healed? Was the reaction primary or secondary? Were any soft tissues involved in the reaction? Often these questions are addressed using methods of gross description, comparative analysis, and differential diagnosis, as well as by referencing paleopathological texts, such as Ortner (2003), and osteological standards for comparison, such as White et al. (2012). It should also be noted that sex and age-at-death estimations should be produced prior to the examination of paleopathological indicators. (See Methods in Chapter 3 for more detail.)

The approaches discussed above have been used to study skeletons from a range of times and places, but the European Middle Ages has a particularly rich pathological
history. This chapter includes descriptions and examples of paleopathologies commonly found in skeletal assemblages from the European Middle Ages.
Dental Disease

Introduction
Dental hygiene was acknowledged, but not commonly practiced, during the European Middle Ages. Extant medical texts reveal medieval physicians’ recommendations of preventative dental care: “In order to prevent tooth rot one should rub the teeth with either a mixture of powdered cinnamon (*Cinnamomum zeylanicum*), and mastic, or powdered marjoram (*Origanum majorana*) and mint (*Mentha sp.*), or nitre [saltpetre]” (Anderson 2004: 422). In addition to the avoidance of tooth rot, the color of teeth may have also been important to some, “Discoloured teeth should be washed in a mixture of wine flavoured with horsemint (*Mentha sp.*) and pepper (*Piper sp.*)” (Anderson 2004: 423). These texts also reveal the existence of oral surgery in the form of tooth extraction, conducted by “barber-surgeons” who were the same people who cut hair and occasionally performed blood-letting to aid the sick (York 2012: 40). Occasionally, archaeologists uncover evidence of tooth cleaning practices which complements the evidence found in the historical sources. For example, during the analysis of skeletal material from the excavation of Fishergate cemetery in Britain, physical anthropologists discovered three males with “polished, abraded buccal tooth surfaces,” and another who “exhibited wear of cementum in a pattern that was consistent with the use of a toothpick” (Duncan 2000: 354). More frequently, however, archaeologists unearth evidence of severe and widespread dental pathologies.

The analysis of teeth from medieval skeletons uncovered during archaeological excavations provides physical anthropologists with an opportunity to explore the reality
of the lack of dental hygiene during this period. For this area of study, it is fortunate that teeth preserve better than any other tissue or bone of the human body due to their highly mineralized composition (97% mineralized compared to 10% mineralization of bone) (Hillson 1996: 148; White et al. 2012: 104). In addition to information about dental disease, tooth analysis can lead to insights about past diet, stress levels, cultural practices (i.e. etchings to teeth), and the correlation between tooth development and biological age throughout history. The exploration of diet is especially important, as it may directly relate to many ailments individuals in the Middle Ages faced:

Written sources indicate that, by present-day standards, medieval diets were unbalanced. Protein, lipid, mineral and vitamin intakes were generally insufficient. Grains and bread formed the major part of peasants’ food (around a kilogram a day) in medieval times and could make up 70% of the total food intake on average. (Esclassan et al. 2009: 294)

The reliance on carbohydrates in the diet explains the prevalence of various dental conditions, such as tooth wear and caries, and also may account for indicators of nutritional deficiencies, such as brief cessations in tooth development (enamel hypoplastic defects).

**Basic dental anatomy**

In order to properly diagnose dental disease, physical anthropologists must first understand the appearance of healthy dentition. During growth from infant to child, the deciduous (or milk) teeth erupt and form an individual’s first set of dentition. The roots of the upper dentition sit within the maxillary bone, while the roots of the lower
dentition sit within the mandible. Throughout childhood, the deciduous dentition is replaced with a larger, in size and in number, set of permanent teeth, ending with the eruption of the third molars (or wisdom teeth). Permanent dentition usually consists of 32 teeth, categorized into four types: incisors, canines, premolars, and molars. Each tooth, regardless of type, has a crown and a root which meet at a junction called the cervix. The entirety of the tooth has a dentin core, but the crown is coated in enamel while the root is coated in cementum. Within the tooth is the pulp cavity, which contains connective tissue, blood vessels, and nerves, as well as dentin-forming cells called odontoblasts (fig. 2.1). The occlusal surfaces of teeth vary greatly depending on type, and the topography of this surface, in addition to the tooth’s position within the mouth, affects its susceptibility to certain dental conditions (Hillson 1996: 6-10).

**Common dental conditions of the European Middle Ages**

Today’s dentists diagnose and work to cure a range of dental ailments. Diagnosing dental disease from skeletal remains, without soft tissue or active infections, is a vastly different process. Paleopathologists routinely confront challenges such as trouble identifying the initial cause of a dental disease, missing data because of postmortem tooth loss, and misleading features due to postmortem damage to teeth or jaw bones.
The most common dental conditions observed in archaeological analysis of dentition from the European Middle Ages include attrition, antemortem tooth loss, enamel hypoplasia, caries, dental calculus, dental abscess, and periodontal disease. The following sections provide basic information on these conditions and how they are diagnosed from human skeletal remains.

**Attrition**

Dental attrition, or tooth wear, is not a dental disease, but it may lead to discomfort and other dental diseases. Attrition occurs due to the masticatory stress put on the teeth while chewing foods or using the teeth as tools, and it appears on the occlusal surfaces as clear wear facets (Hillson 1996: 231-239). Erosion of the enamel may also result from the consumption of highly acidic foods or cultural activities that use abrasive substances, though this type of wear does not result in clear facets (Hillson 1996: 231; Roberts and Manchester 1995: 52). Although some attrition may be beneficial, leading to the elimination of fissures and caries, extreme tooth wear may expose the pulp cavity resulting in pain or serious infections (Roberts and Manchester 1995: 52). Dental wear is also associated with temporomandibular joint degeneration and mandibular, maxillary, and palatine tori, which are bony reactions to high levels of masticatory stress (Roberts and Manchester 1995: 53-54).

Regardless of the cause, dental attrition is easily observable in archaeological dental samples. Studies do not usually end at recording presence or absence of wear, but often proceed with grading levels of attrition intensity and analyzing the direction of erosion. Tooth wear has also become a means for aging skeletal remains (on the
basic premise that more attrition indicates an older age). However, patterns of wear vary between archaeological populations, and methods used to observe one population may not accurately describe another population (Roberts and Manchester 1995: 53). Furthermore, Hillson (1996: 239) notes that “the pattern and degree of wear become more variable with increasing age.”

Although tooth wear is seen in modern humans, it was much more severe during the Middle Ages because of the abrasive foods included in the daily diet and the masticatory pressures needed to eat them. In a study of a medieval French population, Esclassan explains:

Tooth wear in the Middle Ages was much more severe than nowadays. It was intense, rapid, abrasive and generalised, mainly because of the large amounts of abrasive food in the diet and because of the intensity of masticatory pressures. This tooth wear ‘mechanism’ is linked to antagonist teeth and also to hard particles in the food bolus such as phytoliths, quartz, bark, sand and small bones. This high wear progressively altered cusp morphology and gradually made enamel and dentin facets. The wear level depended on the amount of abrasive substances in the diet and also on the structure of the abrasive agents.

(Esclassan et al. 2009: 294)

Bread was a food staple in the European Middle Ages, and the variety most available to the general population, called black bread, was the coarsest in texture. Its abrasive, gritty, and often darkly colored, inclusions would have easily worn down human dentition (Duncan 2000: 355).
**Antemortem tooth loss**

The alveolar portions of excavated skeletons often indicate the individual lost teeth during life and after death (antemortem and postmortem tooth loss). If a tooth is lost during life, the affected tooth socket will gradually fill and remodel with newly forming bone, while if the tooth was lost after death, the “socket will appear pristine” (Waldron 2009: 239). Because of this, archaeologists can confidently determine when a tooth was lost before death, however, they cannot declare reason for the loss. Gross attrition, deep caries, trauma, and intentional extractions are all plausible causes, though Waldron (2009: 239) notes periodontal disease appears to be the most frequent cause (Esclassan et al. 2009: 293). Tooth loss due to caries may mean to an underestimated prevalence of caries in archaeological populations (Esclassan et al. 2009: 293).

**Dental enamel hypoplasia**

One of the best records of childhood stress is the dentition (White et al. 2012: 455-456). Enamel hypoplasia is a dental condition that results from deficiencies in the enamel matrix composition. The defects appear as furrows, pits, or grooves on the enamel surface, usually most visible on the cheek surfaces of the incisors and canines (Roberts and Manchester 1995: 58). Furrows, called linear enamel hypoplasia, are the most common enamel defect, appearing as depressed lines stretching horizontally across the surfaces of the teeth (Hillson 1996: 165-167). Although these defects occur while teeth are developing within the alveolar bones, they remain as a permanent record of childhood development, because unlike bone, teeth are not remodeled throughout life (Roberts and Manchester 1995: 58).
Hypoplastic bands are an indicator of childhood stress that paused tooth development (Roberts and Manchester 1995: 58-61). The stress factors that affect dental growth are divided into two groups, nutritional deficiency and childhood illness, and because the chronology of tooth development is known, enamel defects can be used to reconstruct when an individual faced stress (Roberts and Manchester 1995: 58-61; White et al. 2012: 455-456). In some modern clinical studies, it was possible to correlate enamel defects with a child’s past episodes of diarrhea, a precise connection that unfortunately cannot be made on archaeological samples (Hillson 1996: 166). Archaeological studies have, however, associated other paleopathological conditions on a skeleton, such as a response to anemia (termed cribra orbitalia), with enamel hypoplasia, suggesting a nutritional deficit led to the halt in development (Roberts and Manchester 1995: 60). When using enamel defects to reconstruct childhood illness, it should be noted that although the chronology of tooth development is the same for modern and ancient populations, the rate of tooth development in the past was likely different (Roberts and Manchester 1995: 60).

**Dental calculus**

Calculus accumulation is another common dental condition that, although not a disease itself, may lead to disease. Dental plaque is a material composed of “microorganisms which accumulate in the mouth, embedded in a matrix partly composed by the organisms themselves and partly derived from proteins in the saliva” (Roberts and Manchester 1995: 55). As this substance accumulates on the surface of a tooth, its base, closest to the tooth’s surface, begins to mineralize forming dental calculus. There are
two different types of dental calculus. Supra-gingival calculus forms above the gum and is more common than sub-gingival calculus, which forms on exposed tooth roots (Roberts and Manchester 1995: 55). As saliva is a major component of plaque, surfaces closest to the ducts salivary glands are most susceptible to calculus accumulation (Hillson 1996: 255).

The process of mineralization allows for calculus to preserve on the skeleton, making it easy for physical anthropologists to identify. Though mineralized, dental calculus is also easy to accidentally remove and so, archaeologists must take extra care to protect it during the post-exavcation cleaning processes. The frequency of calculus found in archaeological teeth suggests a lack of attention to substantial plaque accumulation (Roberts and Manchester 1995: 55). Although plaque buildup does not always lead to dental calculus formation, the initiation of mineralization is reliant on plaque. Unsurprisingly, extensive plaque accumulation is correlated with the carbohydrate consumption which increased during the Middle Ages (Esclassan et al. 2009: 294; Hillson 1996: 259).

Caries

Unlike dental calculus, which adds mineralized substances to the teeth, dental caries is a destructive disease. Bacteria living within the plaque on the surface of a tooth ferment sugar from foods and produce acids. These acids soon begin to demineralize the enamel layer of the tooth, exposing the dentin below. The erosion first appears as an opaque spot on the surface of the enamel, but continues to form a deep cavity in the dentin of the tooth (Hillson 1996: 269; Roberts and Manchester 1995: 45-46). Caries are an
infectious disease, transmissible though the passage of certain types of bacteria (e.g. *Streptococcus mutans*) from one individual’s mouth to another (Roberts and Manchester 1995: 44-46). Areas of teeth that easily trap food particles, such as the surfaces between adjacent teeth, are especially susceptible to caries, whereas areas such as the lingual surfaces (near the tongue) are affected at a lower frequency because they are regularly cleansed through natural mechanisms. Posterior teeth are more morphologically complex than anterior teeth, with broader occlusal surfaces covered in pits and fissures, which create a larger area for potential infection (Esclassan et al. 2009: 293; Hillson 1996: 272). Moreover, first molars erupt prior to second and third molars and are exposed to infectious elements for a longer duration (Esclassan et al. 2009: 293). These reasons may explain why in European medieval populations there is the highest number of caries in the molars, specifically the first molars, followed by the premolars, canines, and incisors (Esclassan et al. 2009: 290).

Archaeological studies report that carious lesions are the most frequently found indicators of dental disease, excluding dental attrition which is not technically a disease (Roberts and Manchester 1995: 45). Caries appeared to increase with the shift to agricultural food production—by about 10% in cemetery sites from the Georgia Coast in the United States between 1000 BC and 1550 AD (Roberts and Manchester 1995: 46). The high sucrose content of the diet associated with agriculture further increased during the Middle Ages with the rise in carbohydrate consumption and changes in food preparation and cooking (Esclassan et al. 2009: 293-295; Roberts and Manchester 1995: 47). Additionally, with the drop of cane sugar prices during the medieval period,
even more sucrose was available for consumption, providing nutrients to the carious bacteria living on teeth (Duncan 2000: 353).

Methods for recording caries in a skeletal collection vary. However, basic data collection procedure “should involve stating the tooth affected, the position of the caries on the tooth and the size of the lesion” (Roberts and Manchester 1995: 47). Some studies record the progression of decay systematically, using a categorical grading system: “[N]o caries, less than half the tooth crown destroyed, more than half the tooth crown destroyed, all the crown destroyed” (Roberts and Manchester 1995: 47).

**Dental abscess**

Dental abscesses form when bacteria, and later pus, accumulate in the pulp cavity (Roberts and Manchester 1995: 50). The presence of dental caries or serious attrition increases the likelihood of abscess formation by exposing the pulp cavity (Roberts and Manchester 1995: 50). In addition, abscess may also occur from “enamel cracks after trauma or from spontaneous idiopathic phenomena” (Buikstra and Ubelaker 1994: 55). When the bacteria invade the exposed pulp cavity, the pulp chamber becomes inflamed leading to a pressurized buildup of pus within the jaw (Buikstra and Ubelaker 1994: 55). Eventually, the pressure is too great for the bone to sustain, leading to the formation of a hole, or sinus, on the surface of the jaw bone (Roberts and Manchester 1995: 50). Sinuses on the alveolar bones with healed, rounded edges are good indicators of antemortem disease. However, dental abscess frequency is likely underestimated in archaeological samples, especially with such high caries frequency, because not all pulp chamber infections lead to the formation of clear sinuses. For example, in
medieval Britain, abscesses are estimated to have affected only 2% of teeth (Roberts and Manchester 1995: 57). When identifying abscesses in the jaws of an archaeological specimen, it is important to note the fragility of the alveolar structures, especially on the maxillae, and ensure the sinuses identified are not other holes, called pseudosinuses, produced through postmortem damage (Roberts and Manchester 1995: 50-51).

**Periodontal disease**

The periodontal tissues include the alveolar bones of each jaw, which hold the teeth in the alveolar processes (or tooth sockets), the periodontal ligaments, anchoring the teeth in place, and the surrounding gingivae, which form the gums (Hillson 1996: 260). Factors such as calculus accumulation and trauma can lead to the formation of a gap between the tooth and the periodontal tissues, called a periodontal pocket (Roberts and Manchester 1995: 56). Inflammation of the soft periodontal tissues is diagnosed as gingivitis, but if the reaction progresses to the point where the alveolar bone is affected, it is classified as periodontitis, or periodontal disease (Hillson 1996: 262). Lesion progression from this stage may cause the bone of the jaw to resorb. The roots of the teeth are subsequently exposed until they are no longer anchored in the mouth and fall out (Roberts and Manchester 1995: 56-57).

Periodontal disease is one of the most common dental diseases in modern populations, but it is also frequently diagnosed in archaeological samples. It is likely, however, that this disease is over diagnosed in archaeological populations because of other dental ailments and postmortem damage that depict similar changes to the skeleton (Roberts and Manchester 1995: 57). For example, continuing eruption of teeth
due to attrition may expose the roots of teeth, but this is not the same as periodontal disease (Roberts and Manchester 1995: 57). Other features associated with periodontal disease that may help accurately diagnosis the condition in skeletal remains include inflammatory pitting or new bone formation (Roberts and Manchester 1995: 57).

**Case studies**

The following case studies offer a glimpse of the work that has been done with dental paleopathology for the European Middle Ages.

**Medieval Britain**

Interested in filling a gap in the dental paleopathology literature of the time, Ian Tattersall analyzed a skeletal series recovered from the graveyard of the abandoned medieval village of Clopton, near Cambridge, England, in 1968. The study is fact-driven, providing few details about methods, as illustrated in the following brief explanation: “Whenever an empty socket showed any sign of closing, its tooth was recorded as having been lost antemortem. Error is therefore likely only in those cases where a tooth was lost immediately before death” (Tattersall 1968: 380). Comparisons are made between the sexes in this sample, but no further conclusions or connections to generalized health and diet are made (Tattersall 1968: 380-385).

Tattersall found that 17% of males had antemortem tooth loss, 11.1% of males had caries, and 11.9% of males had dental abscesses. In this sample, an overwhelming amount of individuals were severely affected by periodontal disease, and a notable
amount had enamel hypoplastic defects, though exact frequencies were not calculated (Tattersall 1968: 380-385).

**Medieval France**

In an explorative study of skeletal material from the medieval cemetery at the archaeological site of Vilarnau d’Amont in southwest France, Esclassan and coworkers (2009) aimed to determine the frequency and distribution of caries and tooth wear to further understand the diet of this past group. The collection was estimated to have a short average life expectancy of around 30 years and a normal demography of men, women, and children. 58 adult individuals (29 males, 29 females) from the cemetery met the study’s criteria, with a set of paired mandible and maxilla each holding at least six teeth, offering a total of 1395 teeth for analysis. This selective sample was further divided into two age groups: 20 to 30 years old and over 30 years old (Esclassan et al. 2009: 288).

The methods for the study were established before examination. Teeth were considered to have been lost postmortem if there was a clearly delineated alveolar socket. Dental attrition was graded according to the Brabant index, which scores each tooth a level between 0 and 4 for both degree of dental wear and direction of dental wear. Caries were diagnosed macroscopically. If there was cavitation and clear defects in tooth tissue, the lesions were considered carious and were charted. Caries location was also noted as occlusal, proximal, buccal/lingual, root or pulp. Frequencies were calculated by dividing the number of teeth affected by the total number of teeth examined (Esclassan et al. 2009: 288-290).
Unsurprisingly, the frequency of antemortem tooth loss was significantly higher in the older age category than in the younger category. 8.7% of all teeth were lost during life (first mandibular and maxillary molars most frequently), and 21.9% of teeth (mostly incisors) were lost after death. All individuals in the sample, and 90% of all teeth examined, were affected by attrition (90.6% central incisors, 89.4% lateral incisors, 89.8% canines, 91.3% first premolars, 94.9% second premolars, 99.3% first molars, 93.5% second molars, and 75.6% third molars). Carious lesions were present on 21.9% of teeth, seen most frequently on second molars (57.6%) and least frequently on canines (4.7%). Occlusal and proximal lesions were most frequent (49.7% and 26.5%), while buccal/lingual and root lesions were not common at all (0.7% and 4.0%) (Esclassan et al. 2009: 290-293).

The statistics describing this sample mirror aspects of other medieval populations that have been studied. One oddity is the high frequency of occlusal caries associated with the high degree of wear. Typically, in medieval populations, the coarse, abrasive diet results in high dental attrition, but low caries frequency on the occlusal surfaces, possibly because the attrition quickly wears away carious tissue on the occlusal surfaces. In these other populations, proximal caries, those located on the adjacent surfaces of teeth, are most common. Regardless of location the high frequency of caries reflects the agricultural basis of this low socio-economic class village and the consumption of mainly vegetables, pulses, and grains (carbohydrates) (Esclassan et al. 2009: 293-295).
Medieval Serbia

In 2001, a Yugoslavian team researched dental disease patterns in tooth wear, antemortem tooth loss, caries, dental enamel hypoplasia, alveolar resorption, abscesses, and calculus for two late medieval populations from medieval orthodox church cemeteries on archaeological sites in western Serbia. The sample consisted of 369 skeletons, most in fragmentary condition, from which 105 had usable, nearly complete permanent dentition. These 105 individuals provided 677 maxillary teeth and 1003 mandibular teeth for study (Srejč 2001: 115-116).

Dental attrition was graded on the following four-category scale: “attrition of enamel only; attrition involving dentin; attrition up to the level of fissure of the occlusal surface of the molar teeth, and exposure of the pulp chamber” (Srejč 2001: 116). Cavities were scored based on size and position of lesion, but the caries location and the initial point of infection on the crown were also recorded. Instead of diagnosing periodontal disease, alveolar resorption was recorded through measuring root exposure and identifying signs of inflammatory pitting of the alveolar bone (Srejč 2001: 116).

Over 70% of the individuals had lost one or more teeth before death, lower molars most often and rarely incisors. Dental attrition was the most common condition, affecting 90% of individuals and nearly 70% of the total 1680 teeth examined. Approximately one third of the sample had enamel hypoplasia, mainly on canines and incisors, and nearly half showed supra-gingival dental calculus accumulation. More than 50% of the individuals had dental caries, affecting mainly the mesial and distal surfaces of upper/lower molars and lower second premolars. Caries on the buccal surfaces were uncommon. 83% of the individuals displayed root exposure between the
cemento-enamel junction and alveolar crest exceeding 3 mm, and 19% of all teeth had marked signs of alveolar resorption (Srejić 2001: 116-121).

This medieval Serbian sample population bears a dental pathology profile typical of agricultural late medieval and early modern populations in this region. The high frequency of dental attrition suggests abrasive inclusions were consumed in the likely unrefined foods. Tooth wear may also be the reason behind the low frequency of occlusal surface caries and the high prevalence of alveolar resorption, which can be caused by masticatory stress (Srejić 2001: 121).
Joint Disease

Introduction

It is difficult to determine the prevalence and effects of joint diseases in the human species throughout time. Historical accounts in literature and the visual arts confirm that various joint diseases have been diagnosed and treated for thousands of years, but the real confusion lies in the particularities (Dequeker and Luyten 2008). Terminology is a major roadblock for historians studying the prevalence of joint diseases in antiquity, as many of the conditions have overlapping symptoms. Moreover, certain diseases have been confused for others throughout history. For example, until only about 250 years ago, all rheumatic conditions were categorized as gout (Dequeker and Luyten 2008: 7).

Fortunately, the cloudy story told by texts and art is supplemented with physical evidence on past human remains. Joint diseases are the only degenerative diseases that affect the skeleton, permanently indicating those who suffered. These diseases, along with dental disease and trauma, account for the majority of evidence paleopathologists observe for past disease (Roberts and Manchester 1995: 100). Involving only one joint or many joints in a clearly defined distribution pattern, conditions of the joints can be additive and/or erosive in nature (Roberts and Manchester 1995: 100; Waldron 2009: 30). When examining skeletal material for the lesions of joint disease through radiographic and macroscopic analysis, paleopathologists pay close attention to the “patterning and character” of lesions (Roberts and Manchester 1995: 103).

The effects of joint disease have likely stayed consistent throughout time, leading to a range of symptoms from mild discomfort to severe dysfunction and
deformity. However, the methods utilized for the diagnosis of joint disease differ entirely for living and skeletal populations. Radiography is the only means of examining lesions in living joint disease patients, and with the presence of soft tissue, the visible indications of disease are very different than those on dry bone. This makes it difficult to draw parallels between modern and archaeological populations with regard to the prevalence of joint disease (Roberts and Manchester 1995: 103).

Paleopathologists also have trouble in differentiating specific joint diseases in archaeological samples because many of these ailments result in identical lesions at some of the same joint surfaces in the body (Roberts and Manchester 1995: 100). For this reason, a complete skeleton, and therefore an accurate lesion distribution pattern, along with a working knowledge of unaffected skeletal and joint anatomy is necessary for diagnosis.

**Basic joint anatomy**

The human body has 360 joints. The different anatomical structures of these joints throughout the body shape what diseases are likely to affect them. When grouped by movement, there are three major categories of joints: synarthroses, amphiarthroses, and diarthroses. Synarthroses are immobile joints, such as the sutures of the skull, amphiarthroses are slightly mobile joints, such as the pubic symphysis, and diarthroses are very mobile joints, like the shoulders and hips. Histologically, there are three further categories. Fibrous joints include those like the syndesmoses between the tibia and fibula, and cartilaginous joints are those like the intervertebral joints. Lastly, there are synovial joints, such as all the joints of the digits (Waldron 2009: 25-26).
Synovial joints are the most numerous in the body, and their propensity to movement causes them to be the joints most frequently affected by disease (Roberts and Manchester 1995: 101). These joints are encapsulated externally by a layer of fibrous tissue and lined internally with the synovial membrane, or synovium. The joint space, or cavity, within these tissues contains synovial fluid and is “well supplied with blood vessels, lymphatics and nerve endings which may extend down to the synovial membrane” (Waldron 2009: 24).

Additional, hyaline cartilage pads the articular joint surfaces. Altogether, these soft tissues allow for smooth movement of the synovial joints (fig. 2.2) (Waldron 2009: 25).

The integrity of any joint lies in the combined forces of the muscles, tendons, and ligaments and in the system’s ability to absorb shock, carry weight, and move with reduced friction. When any part of this complex system begins to deteriorate, the entire joint may be compromised. Joint diseases usually begin with degradation of cartilage and exposure of bone, leading to bone destruction and porosity. After cartilage has been worn down in synovial joints, continued use of the joint causes the articular surfaces of the bone to become very hard and polished in a process called eburnation (Waldron 2009: 29). When eburnation creates porosity on a joint surface, synovial fluid may infiltrate the bone forming a subchondral cyst (Roberts and Manchester 1995: 103).

Figure 2.2 Diagram of a synovial joint (Waldron 2009: 26)
Joint disease may also lead to the formation of osteophytes, bony outgrowths on the joint surface, joint margins, or farther away from the joint in a ligament or tendon. Osteophytes may be the body’s attempt at spreading the weight of the load on the joint by increasing the joint’s surface area. If extensive, osteophytic activity may progress to fuse the bones within a joint together, rendering the joint immobile (Roberts and Manchester 1995: 102-103).

Common joint diseases of the European Middle Ages

Osteoarthritis

The most common joint disease in archaeological human groups, and the most common disease seen in archaeological human specimens other than dental disease, is osteoarthritis (Roberts and Manchester 1995: 105; Waldron 2009: 26). Roberts and Manchester (1995: 105) describe osteoarthritis as a non-inflammatory joint disease, but Ortner (2003: 544) notes that, “inflammation does occur in some destructive manifestations,” though it is uncommon. Waldron (2009: 27) also identifies osteoarthritis as inflammatory, including in an explanation of three stages of osteoarthritic disease progression. First, there is “an enzymatic breakdown of the cartilage matrix,” weakening the cartilaginous surfaces of the joints. Next, the cartilage erosion proceeds, releasing destroyed fragments of the tissues into the joint cavity. Stage three is marked by the inflammatory response during which the synovial membrane triggers osteophyte production.

Osteoarthritic changes to bone that are observable by paleopathologists include: marginal bone formation, joint surface bone formation, pitting on the joint surface, a
changed contour of the joint, and eburnation (Waldron 2009: 27). Diagnosis on an archaeological skeleton is based on the analysis of all of these indicators, but “eburnation is the most important of these changes to the paleopathologist” (Waldron 2009: 28). If a joint does not show extreme wear in the form of eburnation, then at least two other osteoarthritic feature must be present for an accurate diagnosis (Roberts and Manchester 1995: 105). The factors that stimulate osteoarthritis include age, genetics, sex, and obesity, though most cases are multifactorial (Waldron 2009: 28). This type of osteoarthritis is termed primary osteoarthritis and usually occurs later in life (Ortner 2003: 546-547). If there is an obvious cause for the arthritic reaction near a joint, such as evidence of a fracture, the osteoarthritis is called secondary osteoarthritis (Waldron 2009: 30). If there are no other clues in the bones near the joint, “[t]here is no means of knowing from the appearance of the joint which of the precipitants was the proximate cause” (Waldron 2009: 31).

Avoiding conclusions about the causes of osteoarthritis, paleopathologists have statistically explored the disease progression at particular joint sights. Although any joint in the body may be affected by osteoarthritis, Ortner (2003: 548) states the joints most frequently affected in decreasing order are: the knee joint, the first metatarso-phalangeal joint, the hip, the shoulder, the elbow, and the acromioclavicular and sternoclavicular joints. Through this type of analysis, paleopathologists have attributed characteristic epidemiologies to certain joints (Roberts and Manchester 1995: 106). For example:

The sterno-clavicular joint is separated into two by a fibrocartilaginous disc, which attaches to the medial end of the clavicle and inferiorly to the first costal
cartilage. The joint is not commonly affected by [osteoarthritis] and when it is, the changes are generally not as marked as in the [acromioclavicular joint] and they are generally more noticeable on the clavicular side of the joint. Men are affected more commonly than women. (Waldron 2009: 35)

These specific epidemiologies help paleopathologists make the most accurate diagnosis possible for both complete and incomplete skeletal material. Observation of osteoarthritis at particular joints has also led to comparative studies between archaeological populations. MacLennan (1999: 18) used osteoarthritis of the hip and shoulder joints to suggest that the prevalence of osteoarthritis during the medieval period was slightly lower than that of the preceding Early Saxon period.

**Erosive osteoarthritis**

Erosive osteoarthritis is not as common as general osteoarthritis, but it has been identified in medieval archaeological samples. Although multiple joint diseases, including osteoarthritis, have destructive force, erosive osteoarthritis is sometimes categorized as a separate disease because of its “particularly aggressive,” deteriorative nature (Waldron 2009: 53). Most frequently occurring in women, erosive osteoarthritis is believed to affect between 4 and 15% of individuals who suffer from osteoarthritis of the hands and is especially damaging to the inter-phalangeal joints (Waldron 2009: 53-54). The disease is characterized by the “presence of eburnation in any of the joints of the hand and asymmetrical central erosions of the [proximal inter-phalangeal joints] and [distal inter-phalangeal joints]” (Waldron 2009: 55).
Osteoarthritis and occupation

Paleopathologists have followed various paths in efforts to draw conclusions about the presence of osteoarthritis in skeletal populations. One of these paths correlates the distribution of osteoarthritis in the skeleton with possible occupation and lifestyle. A similar approach is taken by archaeologists comparing the prevalence of osteoarthritis to a changing economy (Roberts and Manchester 1995: 110). In short, some paleopathologists believe osteoarthritis is a key to paleopathological interpretation, although others find conclusions like this completely ludicrous. The osteoarthritic interpretation has become a very controversial topic indeed.

A study by Merbs (1983) is frequently used to support interpretations of occupation from the distribution of osteoarthritis. In this publication, a sample of skeletons from a Canadian Eskimo group was examined for the presence of osteoarthritis. Upon observing a difference in arthritis distribution between males and females, Merbs concludes males in the group participated in activities such as harpoon throwing and carrying heavy loads, while females carried children and made clothes (Merbs 1983: 138-139).

Conversely, Waldron (2009: 29) states that attempting to derive occupation from osteoarthritis is “futile and doomed to failure.” The argument against this practice of interpretation lies mainly in the multifactorial origin of osteoarthritic lesions. Occupation alone would rarely cause the disease, and other factors such as sex and genetics generally also play a role. Furthermore, the relationship between osteoarthritis and occupation observed in clinical studies may not accurately reflect the patterns seen in archaeological populations (Waldron 2007: 119).
Some authors offer methods that may lead to more accurate conclusions. For example, Roberts and Manchester (1995: 109) offer a potential solution to the osteoarthritis vs. occupation dilemma through the use of younger-aged samples:

To counteract the effects of age it may be useful to study younger individuals; if osteoarthritis is seen here in a particularly high prevalence and specific patterning, it may be possible to suggest an occupationally induced osteoarthritis for this group.

Roberts and Manchester further note that non-metric traits, such as squatting facets on the talus, may be a better means of interpreting occupation (Roberts and Manchester 1995: 110).

**Spinal Joint Disease**

Spinal joint disease, also called intervertebral disc disease (Waldron 2009: 42-43) and spinal osteoarthritis (Ortner 2003: 549), is a universal response to the stress the vertebral column experiences from the erect stance of a biped (Roberts and Manchester 1995: 106). Lumbar vertebrae are most frequently affected by spinal joint disease because they form the final curve of the s-shaped human spine and bear more weight than cervical and thoracic vertebrae (Roberts and Manchester 1995: 106).

In older age, the constant stress that has been placed on the vertebrae begins to cause damage. The first degenerative effects include the degeneration of the intervertebral disc, which is composed of the central nucleus pulposus and the outer annulus fibrosus. Intervertebral disc degeneration may result in a narrowing of the joint space through collapse of the annulus and compression of the nucleus (Waldron 2009:...
In certain individuals, this causes the intervertebral disc to rupture, stimulating osteophytic growth on the margins of the vertebral bodies (Roberts and Manchester 1995: 106). The boney reaction is called osteophytosis and is seen most commonly on the anterior surface of the vertebrae. The osteophytic growth will become more severe with additional mechanical stress, even just that encountered in day to day life. In extreme cases, the boney growths from two adjacent vertebrae may combine and fuse the separate vertebrae together, restricting movement in a condition called ankylosis (Roberts and Manchester 1995: 107). In addition to the vertebral body, the superior and inferior articular facets, as well as the transverse processes, are also often affected by osteoarthritis (Roberts and Manchester 1995: 107).

The less severe symptoms of spinal joint disease are incredibly common, potentially occurring in everyone over the age of forty (Ortner 2003: 549). Although it may be omnipresent in older-aged demographics, variation is expected among individuals. This is a "mechanical induced condition," which suggests that individuals performing heavy manual labor, for example, are more likely to develop osteophytosis than individuals who are sedentary (Roberts and Manchester 1995: 107).

**Rheumatoid Arthritis**

Rheumatoid arthritis is not seen in the archaeological record nearly as frequently as primary osteoarthritis (Roberts and Manchester 1995: 116). Today, rheumatoid arthritis affects only about 1% of the general population, occurring with higher frequency in women than in men (Ortner 2003: 561; Roberts and Manchester 1995: 116; Waldron 2009: 46). As an erosive joint disease, rheumatoid arthritis destroys the membranes of
synovial joints first, then advances into the joint space where the joint cartilage is eroded. The underlying bone is also damaged through the erosion of the joint edges. Furthermore, the progression of this disease generally results osteoporosis, making the overall structure of the affected bones especially weak (Roberts and Manchester 1995: 116). This disease also affects other tissues surrounded the synovial joint, such as the associated ligaments and tendons, and the destruction of these tissues may lead to the partial dislocation of the joints (Roberts and Manchester 1995: 116). These changes to the body result in swelling and pain in the joints, as well as dysfunction and deformity (Roberts and Manchester 1995: 116).

Classified as an autoimmune disease, rheumatoid arthritis is associated with an autoantibody called the “rheumatoid factor,” which is present in about 80% of people with the disease (Roberts and Manchester 1995: 116). Rheumatoid arthritis may affect numerous synovial joints at once, but does so symmetrically throughout the body. The most commonly affected joints include those of the hands and feet, wrist, elbow, knee, shoulder, and cervical spine. The ankle, hip, and sacroiliac joints are also affected, but at a lower frequency (Roberts and Manchester 1995: 116).

Accurate rheumatoid arthritis paleopathological diagnosis depends on recognition of erosive arthropathic holes in the skeleton. These holes can be differentiated from other holes in the skeleton because they are found at the joint margin, joint center, or in adjacent tissues, and they display the following features: cortical destruction, undercut edges, exposed trabeculae, sharp or scalloped ridges, or a scooped floor (Waldron 2009: 51). Paleopathologists must also focus on the distribution pattern of these lesions, which as stated above, is typically symmetrical.
Rheumatoid arthritis is not a common, nor a confidently-posited, diagnosis for archaeological skeletal material. Not only do other joint diseases affect the skeleton in similar ways, it has also been argued that rheumatoid arthritis is “a very recent disease in terms of time” (Roberts and Manchester 1995: 116). Additionally, people in the past may have not lived long enough for the most severe skeletal changes to affect them. Despite this controversy, diagnoses of rheumatoid arthritis have been made for skeletal remains that date back to the third millennium BC, suggesting the disease has a significant history (Roberts and Manchester 1995: 117; Waldron 2009: 47).

**Diffuse idiopathic skeletal hyperostosis**

Unlike rheumatoid arthritis, there is no doubt that diffuse idiopathic skeletal hyperostosis, or DISH, is a truly ancient disease—the earliest case of DISH in the paleopathological record is that of a 40,000 to 73,000-year-old Neanderthal skeleton (Roberts and Manchester 1995: 120). More recently, evidence of DISH has been identified in skeletons from various cemeteries in medieval Europe. Modern cases of DISH appear to be associated with obesity, late onset (type II) diabetes, and a sedentary lifestyle, but its underlying cause is unknown (Roberts and Manchester 1995: 120; Waldron 2009: 75). Modern statistics suggest 4% of men and 2.5% of women are affected by DISH, but males older than 50 years are affected at the highest frequency (Waldron 2009: 74).

DISH affects the skeleton with a “gradual and complete fusion of the spine, particularly in the thoracic region, with retention of integrity of vertebral body surfaces and apophyseal joints” (Roberts and Manchester 1995: 120). Ligaments and tissues of
the spine, as well as cartilages of the neck and spine, ossify and fuse to the solidifying vertebral column (Roberts and Manchester 1995: 120). In addition to the spine, DISH may also produce boney spurs elsewhere in the body, such as around the calcanei and the patellae (Waldron 2009: 73).

One of the difficulties in diagnosing DISH in skeletal remains is the risk of confusing it with ankylosing spondylitis, an autoimmune disease that also results in the fusion of the spine (Roberts and Manchester 1995: 120). These two diseases have certain differentiating characteristics:

DISH is usually found in older males and consists of characteristic thick, flowing spinal osteophytosis and enthesopathies extra spinally, but there is usually no fusion of the small vertebral joints or the sacroiliac joints. [Ankylosing spondylitis] has thinner, vertically orientated spinal syndesmophytes, fusion of the small vertebral and sacroiliac joints and no extra spinal bone formation. (Roberts and Manchester 1995: 121)

Proper diagnosis of DISH calls for the presence of at least four fused, contiguous vertebrae on the right side of the thoracic vertebral column (Waldron 2009: 77). The characteristic highlighted by most sources is bone formation that looks like “candle wax” melting down the anterior surface of the vertebrae (Roberts and Manchester 1995: 120; Waldron 2009: 73; White et al. 2012: 443).

Much thought has gone into the seemingly high prevalence of DISH in monastic cemeteries (e.g. the 8.6% frequency in the twelfth to sixteenth century AD Merton Priory cemetery in England compared to the 2.8% in the modern population) (Roberts and Manchester 1995: 121). Monks and other individuals of high status clearly had
surplus food and ate very well, not to mention their access to ever-flowing supplies of beer and wine. These factors make it likely the monks were overweight or obese by the time they reached middle age. Waldron (2009: 76) explains, “[f]ish was abundant during this period, as was all manner of game—capon, chicken, ducks, geese, egret, herons, pheasant, partridge, pigeons, quail, teal and swan are all mentioned in the account books of the fourteenth century Abbot of Westminster.” Here, monks were given a daily allowance of 6,207 calories and were unlikely physically active (Waldron 2009: 76). Therefore, it comes with no surprise that these individuals faced the consequences by succumbing to obesity, type II diabetes, and the correlated diseases like DISH (Patrick 2005).

**Case Studies**

Comparative population-wide studies, as well as studies cataloging anomalies, have been conducted for joint diseases in medieval European archaeological samples. Population-wide studies provide archaeologists and historians with insights into the epidemiological status of the medieval people, but the individual studies are important in confirming the presence of particular past ailments and diseases. Waldron (1992: 235) notes the goal of many paleopathological studies: “Aspects of particular interest to the palaeopathologist are the extent to which the prevalence and the distribution of the disease may have changed over time and those factors that may be related to any differences that are observed.”

In 1992, Waldron published a large study of medieval osteoarthritis prevalence in an effort to fill a gap in the literature on osteoarthritis in antiquity. His study sample
consisted of 369 individuals from a Black Death plague pit (fourteenth century) on the site of the old Royal Mint in London. With this large of a sample size, Waldron is able to make generalized conclusions about the epidemiological presence of osteoarthritis in this population. He was also able to make helpful comparisons with other large archaeological skeletal samples and with modern clinical studies. Skeletal examination began sex and age-at-death estimations for each individual before it progressed to the observation of skeletal indicators of osteoarthritis. Osteoarthritis was diagnosed if there was eburnation on a joint surface or if at least two of the following were present: “marginal osteophyte, deformation of the normal joint contour, pitting on the joint surface or new bone on the joint surface” (Waldron 1992: 235).

Waldron’s first conclusions are specifically about the medieval population found in the Black Death plague pit. Osteoarthritis appeared to increase in frequency with increasing age, and unlike in most modern populations, the joint disease was more common in males than in females. Osteoarthritis most frequently affected both sexes in the spine and shoulder, but males experienced osteoarthritis of the wrist more frequently than females, and females experienced osteoarthritis of the knee and foot more frequently than males. Interestingly, unifocal joint disease was the most common distribution, with approximately two-thirds the sample experiencing osteoarthritis at only one site (Waldron 1992: 236-237).

Moving beyond this sample in isolation, Waldron then discussed where the study fits into the previous literature on osteoarthritis. Although noted that it is difficult to draw comparisons between archaeological and living populations due to the differences in paleopathological diagnosis and clinical diagnosis, Waldron provides a
graph comparing medieval and modern populations to demonstrate the differences in frequency. It appears the medieval population experienced a higher prevalence of osteoarthritis, especially in the 45+ years age range. Waldron suggests that with this comparison, and with comparisons between the medieval sample and an eighteenth to nineteenth century skeletal sample from Spitafields, the prevalence of osteoarthritis may not be as important and the pattern of osteoarthritis. After analyzing frequencies in the two skeletal populations, “there is not great disparity in the pattern of joints affected” (Waldron 1992: 239). This type of study is significant because it reveals details regarding medieval disease as well as the consistency of osteoarthritic distribution on the skeleton in past populations and into today.

Cunha (1996) presents another population-wide study of osteoarthritis for the cemetery of the medieval church of S. João de Almedina in the City of Coimbra Portugal. The goal of this study was to offer an alternative to the current skeletal age estimation techniques through the use of osteoarthritis as an indicator of past demographic structure. The data produced, however, is also useful for understanding osteoarthritis in medieval Europe (Cunha 1996).

Skeletal material was aged and sexed before analysis for osteoarthritis, revealing the sample size consisted of 14 probable males, 15 probable females, and 7 undeterminable skeletons, with approximately 50% within a 50+ years age range. In this sample, as in the study discussed above, there is an increased frequency of osteoarthritis with increased age, leading to a statistic of osteoarthritis in 100% of individuals aged 55 or older at death. The spine and shoulder were affected at the
highest frequency, followed by, in decreasing frequency, the elbow, knee, and wrist (Cunha 1996).

Both the populations discussed by Cunha (1996) and Waldron (1992) mirror modern clinical data in that they show increased osteoarthritis with increased age. However, Cunha notes a subtle difference in the medieval populations that may suggest medieval and modern osteoarthritic activity is not quite the same—the medieval skeletal populations appear to experience a linear increase in frequency, while modern populations experience an exponential configuration after the age of 50 or 60 years. This suggests that parallels drawn to modern populations, such as those by Waldron, may not be as accurate, or as important, as the comparisons to osteoarthritis in other medieval samples. In tune with Waldron, however, Cunha emphasized the comparison of osteoarthritic distribution, stating that medieval populations “present a similar pattern” (Cunha 1996: 154).

Moving away from population-wide studies, these archaeological individuals are revelatory—confirming the presence of rheumatoid arthritis and erosive osteoarthrosis in medieval Europe. A late fifteenth century burial from the lay cemetery of Abingdon Abbey in Oxfordshire was excavated and revealed one of the few convincing archaeological specimens with rheumatoid arthritis. Disturbed from successive burials, this grave yielded the partial skeleton of an adult female. Overall, the bones of this individual were light in weight with very low bone density, and many of the joints, especially those of the left wrist and hand, showed severe marginal cortical erosions. The bone erosion was not typically coupled with the formation of reparative new bone or periostitis. Important in diagnosing rheumatoid arthritis, this individual
displayed very symmetrical lesions of erosive polyarthropathy in the shoulders, elbows and hands (Hacking et al. 1994: 251-252).

Although nothing can be said about epidemiological prevalence with a skeletal sample of one individual, this case study does speak to the presence of rheumatoid arthritis in Europe at the time. This is important because the antiquity of rheumatoid arthritis has been heatedly debated (see above). In 1974 and again in 1990, it was suggested that rheumatoid arthritis was a modern disease and cases from the past were simply misdiagnosed. More recently however, case studies such as this one by Hacking, confirm that, although rare, rheumatoid arthritis has been present in Europe for hundreds of years (Hacking et al. 1994: 255).

Another seemingly uncommon joint disease of the European Middle Ages is erosive osteoarthritis. A case study by Rogers and coworkers (1991) identifies this disease in a late fourteenth to early sixteenth century adult female skeleton. This conclusion is based upon rather shaky ground, as the skeleton is very incomplete with only “the distal left humerus, the left and right radius and ulna, all five lumbar vertebrae, the first sacral segment, part of the left ilium and most of both hands” (Rogers et al. 1991: 151).

Arthritic lesions were frequent in the joints of the wrists and hands, however the location of lesions within these joints differed. The carpometacarpal and metacarpophalangeal joint lesions were marginal, and the interphalangeal joint lesions were central with some new bone formation around the margins (Rogers et al. 1991: 151). The central positioning of lesions and their distribution amongst the hands and wrists, as well as the presence of some bone proliferation and ankylosis at one joint
supported the diagnosis of erosive osteoarthritis. Other conditions with similar skeletal indicators, such as rheumatoid arthritis and gout, were ruled out but not with complete certainty because of the partial status of this skeleton. The data available may appear to confirm the presence of erosive osteoarthritis in medieval Europe, however in their conclusion the authors noted their possible skepticism by reiterating the disease’s rarity:

We have examined well over 5000 skeletons from various sites in the UK from all periods from the Neolithic to the mid nineteenth century, and although osteoarthritis affects substantially more than a quarter of all adult skeletons this is the only one that in any way resembles erosive osteoarthritis. (Rogers et al. 1991: 153)
Infectious Disease

Introduction

In the past, before the use of effective medical treatments such as antibiotics, bacterial and viral infections were responsible for the majority of human deaths (Roberts and Manchester 1995: 124). Some infectious diseases leave pathognomonic marks on the human skeleton, while others do not involve bony tissues at all or are so lethal they kill the infected person before the skeleton can react. Paleopathologists explore these diseases, but oftentimes, specialists from a number of fields join together in attempts to understand the effects of epidemics on past societies. Though archaeologists may be the first on the scene to unearth physical evidence from years ago, they soon turn to osteologists and paleopathologists for demographic inferences and pathological diagnoses derived from morphological indicators on human skeletal remains. Vertebrate and invertebrate zoologists are also involved in this study of ancient disease, analyzing the remains of animals, which act as disease reservoirs and vectors. Microbiologists investigate the bacterial agents of diseases, sometimes confirming its presence in human and animal remains through the isolation of ancient DNA. The conclusions reached by these interdisciplinary studies are significant and vastly different from the conclusions reached by other types of paleopathological analysis.

Non-specific bacterial infections

Bacterial infections were common in the past, as they are today, however without access to antibiotics, these infections were a genuine threat to their victims.
Paleopathologists can diagnose generalized bacterial infections on a skeleton through the identification of two different patterns of skeletal lesions.

The first is called periostitis, or a periosteal reaction, and may be triggered by infection or trauma at any location on the body. Periostitis is both a disease in itself, as well as a symptom of multiple infectious diseases (Ortner 2003: 208). This reaction is therefore very common in the archaeological record, and when observed in large osteological collections, its prevalence may be a good indicator of general health of the population. Periostitis is an inflammatory reaction of the periosteum, a thin, soft tissue sheath that covers the outer surfaces of bones. When this soft tissue becomes irritated, it responds by swelling and separating from the surface of the bone. The inner layer of the periosteum, which has an osteoblastic capacity, then reacts to the fluid-filled space between it and the cortical bone surface by laying down tracks of new woven bone (Lewis et al. 1995: 77; Ortner 2003: 206). Ortner (2003: 206) notes that woven bone always has “a porous-appearing surface that is partially due to the irregular orientation and distribution of the mineralized collagen fibers.” This abnormal porosity is a recognizable indicator of a periosteal reaction for paleopathologists to observe. In the cases of trauma or a localized infection, the reaction may cover only a single area of a bone. However, when an individual has suffered a systemic infection, entire faces of a bone may be affected in a bilateral pattern. The bones of individuals who have recovered from an infection will show the incorporation of the woven bone into lamellar bone, while those with chronic infections or infections at the time of death will show active woven bone. Lamellar bone is smoother than woven bone, with striations and continuity with the original cortical, or compact, bone (Lewis et al. 1995: 77).
Bacteria may also enter the bones, typically through a wound, and spread to infect the medullary cavity (White et al. 2012: 444). This event leads to a specific skeletal reaction called osteomyelitis. Roberts and Manchester (1995: 126) describe this pathological process as one of “bone destruction and pus formation, and simultaneous bone repair.” The bacteria causing the infection, often *Staphylococcus* bacteria, produce pus which fills the medullary cavity and eventually drains through openings in the bone called cloacae (White et al. 2012: 446). When bone repair in response to infection is extensive, the entire outer surface of a bone may become covered in a layer of coarsely woven bone termed an involucrum (White et al. 2012: 446). Both periosteal and osteomyelitic reactions indicate infections that could have progressed to infect the blood. In these cases, it is likely the infection led to the individual’s death (Roberts and Manchester 1995: 129).

**Tuberculosis**

Evidence of tuberculosis can be traced back to ancient Egypt, as early as 3700 BC, where artists depicted figurines with tuberculous symptoms (Manchester 1984: 163). This infectious disease is caused by human-to-human passage of the bacteria *Mycobacterium tuberculosis*, or through cattle-to-human passage of *Mycobacterium bovis*. Although *M. tuberculosis* is responsible for most of today’s tuberculosis cases, both types of bacteria affected humans in the past. Through studying both pathogens, paleopathologists and biologists can begin to understand the disease’s evolution and dissemination into human populations.
A *M. tuberculosis* infection typically manifests itself in the human respiratory tract, but the bacteria may also affect other body systems including the skeleton. Infection of the skeleton yields destruction and cavitation of the cancellous bone without extensive associated reactive bone formation. Many areas of the skeleton can be affected, but the vertebral column is most commonly the primary focus because of its proximity to the lungs, followed by the os coxae (White et al. 2012: 444). Bone destruction in the spine may lead to the collapse of one or several vertebral bodies, causing a sharp angle, or kyphosis, in the spine. This vertebral manifestation of tuberculosis is often referred to as Pott’s disease, and it is pathognomonic for tuberculosis, easily prompting diagnosis by paleopathologists. Other skeletal indicators of the disease include tuberculous arthritis of the hip or knee joints (Manchester 1984: 162). Despite the numerous skeletal indicators, data suggests only about 5 to 7% of cases show bone changes, making it likely that the prevalence of past tuberculous infection based upon morphological bone changes is underestimated (Mays et al. 2001: 298).

It has been hypothesized that the first human tuberculous infection was through *M. bovis* around the time that humans began to domesticate large herds of goats (8000-7700 BC) and cattle (7000-6000 BC) for meat and milk. Osteomyelitic changes in a skeleton from 2500-1500 BC mark the oldest tuberculosis case in Northern Europe, but the oldest known case in Britain is that of Pott’s disease in a female skeleton from only the third to fifth century AD (Manchester 1984: 165). Factors such as the growth of towns into cities and the increased proximity to the meat of cattle through the development of butchers’ markets may explain why there was a sudden increase in
tuberculosis infection during the Middle Ages (Manchester 1984: 166). Conversely, further increase of infection may be attributed to population depletion after the Black Plague in the mid-fourteenth century, resulting in “a reduction of living standards and consequent health standards” (Manchester 1984: 166). Tuberculosis in medieval England has been thoroughly explored, with microbiological studies confirming the presence of *M. tuberculosis* in individuals with the associated skeletal indicators (Taylor et al. 1999). Studies of this nature provide a new avenue for paleopathological analysis that is less dependent on morphological change.

Taylor and coworkers (1999) report using methods of PCR (polymerase chain reaction) DNA amplification to analyze bone samples from a medieval site in London for the presence of *M. tuberculosis*. The skeletal material used for this sample had been excavated from a graveyard overlying one of London’s Black Death cemeteries located on the site of the old Royal Mint. Because of the graveyard’s association with a Cistercian abbey, the skeletal material was dated to between 1350 and 1538 AD. Samples were taken from three bones on two separate skeletons—one from the fused wrist of a middle-aged male and one each from the first and second lumbar vertebrae of a male aged between 15 and 25 years old. The middle-aged male showed signs of healing from his infection, while the younger male showed large, active cavities on both vertebrae (Taylor et al. 1999).

Bone from each of these samples was powdered, and the DNA was extracted and amplified using PCR. The PCR primer in use for tuberculosis identification, IS6110, was a *M. tuberculosis* DNA fragment that appears at multiple locations within the genome. A gene encoding the beta-subunit of RNA polymerase, which modern
tuberculosis has altered to have rifampicin-resistance, or drug resistance, was also used to ensure the antiquity of the isolated *M. tuberculosis* DNA. Furthermore, the DNA extracts were tested using PCR amplification primers from *M. bovis* to verify *M. tuberculosis* as the true infectious agent. The results of these experiments confirmed the morphological diagnosis of tuberculosis, as well as the additional specificities that the strain was drug sensitive and was not closely related to *M. bovis* (Taylor et al. 1999).

Another study published in 2001 confirmed the presence of *M. tuberculosis*, and not *M. bovis*, in skeletons from medieval England with tuberculous bone changes. Unlike the skeletal material from the Black Death cemetery in London, this study’s samples were collected from the rural agrarian site of Wharram Percy, which dates from the tenth to the sixteenth century AD (Mays et al. 2001: 299). The comparison of data from these two studies is important because *M. tuberculosis* is a density-dependent disease which is more likely to be prevalent in cities (Manchester 1984: 162). Additionally, *M. bovis* may be found more frequently in agrarian towns where people were in close proximity to cattle (Taylor et al. 1999: 899). Nine human skeletons were chosen for this study based on the following criteria:

> [P]redilection of lesions for the lumbar and thoracic vertebral bodies and the large joints of the appendicular skeleton; lesions that are mainly destructive, producing cavitation into the cancellous bone of the long-bone ends or vertebral bodies with little new bone formation; sequestra are characteristically absent; frequent vertebral body collapse with spinal kyphosis; and spinal disease is generally monofocal. (Mays et al. 2001: 300)
Serving as controls, two skeletons with causes of death unrelated to infectious disease (both showed fatal cranial trauma) were also tested for the presence of *M. tuberculosis*. Furthermore, multiple rib fragments with periosteal reactions from cattle at Wharram Percy were subjected to DNA testing for the faunal-affecting *M. bovis*. In cattle, as in humans, the lungs are the primary center for tuberculous infection, but it is unconfirmed as to whether periosteal reactions on the ribs can result from lung infection (Mays et al. 2001).

A series of bimolecular tests yielded positive results for the presence of *M. tuberculosis* in each of the nine suspected human skeletal samples. Although the criteria for a morphological tuberculosis diagnosis were stringent, one of the nine skeletons had only “superficial cavitation on the body of the fourth lumbar vertebra and a similar, smaller erosion on the fifth” (Mays et al. 2001: 304). These slight skeletal changes could align with a number of conditions, but the DNA tests confirmed the presence of *M. tuberculosis* suggesting this may represent a case in the early stages of skeletal change or rather that the skeletal changes were unrelated to tuberculosis altogether (Mays et al. 2001: 306). This reinforces earlier claims that tuberculosis is likely underestimated in archaeological populations because of the low frequency of tuberculous skeletal change (Manchester 1984: 298). Further tests also confirmed that all nine samples were infected with *M. tuberculosis* and not *M. bovis* (Mays et al. 2001: 306).

Each of the cattle rib samples tested negative for the presence of *M. bovis*. The results made it clear that cattle were not the reservoir for the infections the humans at Wharram Percy suffered, but they also raised questions about the infection the cattle
faced. Were the periosteal reactions due to a different disease? Were the cattle of Wharram Percy completely tuberculosis free? Was the DNA poorly preserved in cattle ribs? One of the most important questions reaches back to the human infection, asking how this small town sustained a bacterial disease if not through an animal reservoir. Manchester (1984: 166) suggests that due to the increased trading that occurred during the Middle Ages, rather than viewing villages like Wharram Percy as individual units, the “townships and associated rural communities should be regarded as population aggregates acting as a single unit in the dissemination of infectious disease.” In short, this disease data may serve as proof that Wharram Percy, though rural, was interconnected with other settlements.

**Leprosy**

Another *Mycobacterium, Mycobacterium leprae*, is responsible for the infectious disease leprosy. The pathogenicity of *M. leprae* is dependent on the infected individual’s immune status. Tuberculoid leprosy results when individuals have high resistance to the bacteria, possibly explained by the “cross-immunity between tuberculosis and leprosy” which allows for individuals with tuberculosis to “benefit to a certain extent from a protection against leprosy” (Manchester 1984: 172-173). Individuals with low resistance may suffer lepromatous leprosy, which has been speculated to be the most significant form of leprosy in the past (Manchester 1984).

Archaeologically, leprosy is diagnosed when skeletal material shows inflammation and deformation of postcranial portions, most frequently the tibiae and fibulae. Rhinomaxillary features are also frequently affected, resulting in the:
absorption of the anterior nasal spine, absorption of the alveolar process of the maxilla, inflammatory pitting and possible perforation of the oral and nasal surfaces of the palatine process of the maxilla and... the smooth absorption of the inferior zones of the margins of the nasal aperture. (Lewis et al. 1995: 78)

The first medieval leper in Denmark was unearthed by Møller-Christensen and featured leprous changes such as a markedly flattened nasal aperture, perforation of the palate, and diaphyseal atrophy in the feet (Møller-Christensen 1953: 118-122). Møller-Christensen was the first archaeologist to describe the bone changes of leprosy and his conclusions have shaped the criteria used by today’s paleopathologists for leprosy diagnosis.

The historic record also guides archaeological explorations of leprosy. In the first half of the thirteenth century, it appears England faced its peak of leprosy infection, “requiring some 200 lazar houses for the care of its victims” (Manchester 1984: 169). Excavation of leper hospital cemeteries provides archaeologists with a sample that is likely high in leprosy cases. For example, Lewis, Roberts, and Manchester (1995) identified leprous bone changes on fifty of 355 skeletons excavated from the medieval cemetery of the Hospital of St. James and St. Mary Magdalene in Sussex, England. In addition to the several identifiable leprosy cases, “it is possible that some skeletons included in [the] sample are of people who were suffering from leprosy but died early in the course of the disease before pathognomonic bone involvement occurred” (Lewis et al. 1995: 80).

However, it was not only Britain that experienced the effects of *M. leprae* during the Middle Ages. Until the sixteenth century, leprosy was endemic all over
Europe. Schuenemann et al. (2013) applied DNA capture and high-throughput DNA sequencing techniques to eleventh to fourteenth century human skeletal remains, confirming the presence of *M. leprae* at four different locations in medieval Europe. The twenty-two medieval skeletons used for sampling were excavated from cemeteries in Denmark, Sweden, and the United Kingdom. These samples were screened for the pathogenic bacteria with a highly effective procedure, producing results with up to 40% mapping to current *M. leprae* reference genome fragments. In total, the twenty-two samples yielded five usable medieval *M. leprae* strains. Not only does this type of study confirm the presumed indicators of disease on the skeleton, it also allows for comparison between ancient and modern pathogenic bacterial genomes (Schuenemann et al. 2013).

**The Black Plague**

The bacterial species *Yersinia pestis* is the infectious agent behind both the pneumonic and bubonic plagues, and is the presumed culprit behind the Black Death of Europe in the fourteenth century and other historic plagues. The Black Death, or the Black Plague, with its lethality and grim consequences, still remains powerfully intriguing to archaeologists, scientists, and historians alike. Although this infectious disease does not leave marks on the skeletons of its victims, that has not prevented it from being subject to extensive epidemiological study.

For example, in 1986 the Museum of London recovered about 600 skeletons from the Royal Mint Cemetery, the first Black Death emergency cemetery uncovered in London. This cemetery held many individual graves, two mass trenches, and a mass
burial pit, together composing a large assembly of well-preserved skeletons. Historical records suggest 2,400 individuals were buried here during the fourteenth century, with an estimated rate of 200 burials a day during the peak of the plague in England (April 1349 AD) (Antoine and Hillson 2005). Through osteological analysis, paleopathologists estimated the sex and age at death of each of the skeletons.

A study following this excavation attempted to draw conclusions on the effects of childhood famine on adult disease, focusing on the skeletons of individuals who grew up during the Great Famine (1315-1317 AD) and died during the Black Death epidemic. Bone and tooth development is temporarily halted during times of stress, for example nutritional depletion, and this cessation may leave Harris lines within the trabecular bone and linear enamel hypoplasia in developing teeth. Bones are continuously remodeled during life, but teeth are not, making enamel hypoplasia a more reliable indicator of developmental stress (see Dental Disease section). Research began with the isolation of a study sample of thirty skeletons with estimated ages between 30 and 40 years and a negative control of seven skeletons that should have been born after the Great Famine. The pattern of growth cessation in teeth of the thirty individuals was compared to a chronology of the famine that was based upon the records of spiking wheat prices at this time (Antoine and Hillson 2005). Although the results of this study have not yet been published, a few conclusions seem possible. First, the majority of skeletal remains aged between 30 and 40 years may more frequently show indicators of childhood stress than the control. This difference may be attributed to the temporary cessation in growth and development during the Great Famine, however, further interpretations may vary. One interpretation may suggest the
childhood stress consequently made the individuals more susceptible to the plague. On the other hand, one could also propose that the demarcations of childhood stress on a person who lived to be 30 years of age indicate that person was a healthy individual who was able to live and grow during times of starvation. Alternatively, the skeletons aged between 30 and 40 years may show fewer or equal skeletal indicators of stress than the control. Potentially, this suggests that these individuals were less severely affected by the Great Famine than previously thought.

A more recent project in Aude-Languedoc, southern France, revealed another Black Plague cemetery dating to the eighth through fourteenth centuries. Excavation identified a total of 149 graves, including a number of individual graves and three mass graves—two of them holding two complete individuals and the third holding the remains of five individuals. Radiocarbon dating indicated two clear phases: the first representing the early Middle Ages (eighth to tenth century AD), with graves lined by rocks or covered in sandstone slabs, and the later dated to the classic Middle Ages (eleventh to fourteenth century AD), with wooden coffins or no burial container at all. The fourteenth century date in combination with the presence of three mass graves raised suspicions about the potential presence of plague victims in the cemetery (Kacki et al. 2011).

All nine of the individuals from the mass graves and fourteen individuals from single graves were tested for the presence of *Y. pestis*. Instead of the previously used paleomicrobiological technique that isolated ancient DNA, researchers employed a new paleoimmunological technique that detects a glycoprotein specific to the outermost membrane of *Y. pestis* bacteria. Microbiologists often face problems
isolating ancient DNA because of DNA’s quick degradation rate, but glycoproteins degrade much more slowly. Therefore, these molecules were proposed to be a more effective target for identifying ancient disease. Seven out of the nine mass grave skeletons and four of the fourteen single grave skeletons tested positive for the plague bacteria. Negative control samples consisted of skeletal material taken from graves in the earliest phase of the cemetery and from fourteenth to fifteenth century burials of the Eglise de Cordeliers graveyard in Hautes-Alpes, France. This area was previously proved to have been “plague free” in the 1300s, providing samples that consistently tested negative for the presence of Y. pestis (Kacki et al. 2011).

The convincing evidence for this Black Death cemetery led to further conclusions and questions. For example, at the time of the plague, 90% of France’s population lived in rural communities, but almost all historic records cover solely urban communities. This project helped archaeologists interpret the reactions of smaller communities to an epidemic. Additionally, the few other rural Black Death burial sites that have been excavated each show different treatment of corpses, which has caused confusion and prevented conclusions from being made about burial practice during times of epidemic. With the new information from the excavation of this cemetery, archaeologists have begun to draw generalized conclusions such as, “the presence of several graves containing multiple bodies in the same location and belonging to the same funerary phase is consistent with increased mortality” and “only when the highest peaks of mortality were reached, the customary funerary practices were discarded and mass graves were dug” (Kacki et al. 2011: 586). More specific conclusions on how rural communities respond to natural disasters like the plague may never be drawn because
of the vast amount of variability in the possible experiences. For example, the unique burial practices discovered through this excavation may be representative of the mixture of emotions people felt during the plague epidemic, such as overwhelming sadness for the deceased, utter terror of one’s own death, and complete disgust with the number of corpses that needed to be interred.

Further studies of the Black Plague cover a range of disciplines, such as zoological explorations into the vertebrate host and invertebrate reservoir of *Y. pestis* (Hufthammer and Walløe 2013). Uncovering the secrets of ancient plague and other infectious diseases is a multidisciplinary feat, each field “unearthing” fresh evidence—even if it’s not with a trowel. In addition to new theoretical perspectives, a topic like ancient plague becomes a means for testing new scientific methods, such as the efficacy paleoimmunological techniques on ancient glycoproteins. Interdisciplinary studies like these will continue to push the field of archaeology forward.
Chapter Three: Ailments of the Abbey

Methods of bioarchaeology

When skeletal analysis methods are thoughtfully chosen and applied, human remains can offer a wealth of information on past demography and health, especially in population-wide studies. This section highlights a fraction of the many methods utilized by physical anthropologists to estimate biological sex, age at death, and living stature from human skeletal remains. Like all archaeological material, human skeletal remains are historically contingent because of the ever-changing environmental factors that affect them. Therefore, this bioarchaeological material must be interpreted within the best possible framework for each specific case.

The case studies described in the latter two sections of this chapter have small sample size numbers meaning population-wide analysis was not possible. However, a skeletal analysis of sex, age at death, and stature was completed to obtain as much data as possible about these individuals. This data is vital to the interpretations explored in Chapter 4. It is important to note that the case studies are medieval burials from northern France, and that many of the methods utilized in this chapter are derived from populations that stray from medieval France in time and location. Therefore, whenever possible, comparisons were drawn using additional, more relevant sources in an attempt to make the most accurate inferences from the data collected (Buikstra and Ubelaker 1994; Mays 1998).
Biological Sex Estimation

One way biological anthropologists estimate the sex of human skeletal remains is through the observation of morphologic traits of the pelvis and skull, both of which are highly sexually dimorphic skeletal structures. Morphological traits are recorded or scored for their presence/absence or on the degree of expression based on visual comparison to a set standard. This method of morphological comparison produces accurate data for sex estimation, as Krogman and Iscan proved with the following accuracy rates for morphological attributes: “entire skeleton = 100%; skull alone = 90%; pelvis alone = 95%; skull plus pelvis = 98%; long bones alone = 80%; long bones plus skull = 90-95%; long bones plus pelvis = 95% +” (Krogman and Iscan 1986: 149).

Studies by Phenice (1969) favor three morphological traits of the pubis for estimating sex. With observation of ventral arch, subpubic concavity, and ischiopubic ramus ridge, Phenice claimed there is an accuracy rate approaching 100% (Phenice 1969: 300-301). In 1989, Lovell (1989) put this surprisingly high accuracy rate to the test and results showed a much lower accuracy rate of 83%. In her study, however, Lovell might have undermined the method’s ability with a small sample size of 50 individuals compared to the Phenice study sample size of 275 individuals. The true accuracy rate most likely lies between the two, providing valuable data for sex estimation, but never certainty. According to Lovell, one of the reasons why the accuracy rate cannot be as high as Phenice had stated is because of changes in morphological traits that come with increasing age of the individual (Lovell 1989: 119). For this reason, among others, both age and sex are estimated before drawing conclusions about an individual. Other morphological traits of the os coxae, including the greater sciatic notch and preauricular
sulcus, offer additional data for sex estimation, and methods for these observations can be found in “Standards For Data Collection From Human Skeletal Remains” (Buikstra and Ubelaker 1994: 16-19).

After the os coxa, the skull is the next best source data for morphological sex estimation. In their 2006 study, Williams and Rogers observed fourteen morphological traits of the skull on the skeletal remains of fifty adult white European individuals. Finding an overall 92% accuracy rate in cranial morphological sex estimation, Williams and Rogers stated, “[I]t is possible to achieve high accuracy and precision using a discrete number of morphological features of the skull to determine the sex of unknown skeletal remains” (Williams and Rogers 2006: 732). The scoring methods for five of these morphological features, the nuchal crest, mastoid processes, supraorbital margins, glabella, and mental eminence, are provided in “Standards For Data Collection From Human Skeletal Remains” (Buikstra and Ubelaker 1994: 20). Although these methods do not include all fourteen traits from the Williams and Rogers publication, the study suggests the method of cranial morphological sex estimation is accurate even without accounting for all fourteen traits (Williams and Rogers 2006: 734).

The sex of skeletal remains can also be estimated using metric measurement calculations. These calculations can produce estimations of 82-89% accuracy for cranial measurements, 88-90% accuracy for joint size measurements, and up to 94% accuracy for multivariate models of postcranial measurements (Giles and Elliot 1963: 67; Spradley and Jantz 2011: 289). Postcranial measurements, specifically the ischial-pubic index and femoral head, have a 90% accuracy rate and should hold substantial
weight in the final sex estimation (Jane Buikstra, pers. comm.). Because metric analysis involves the measurement of many specific lengths, however, this method may not be convenient for physical anthropologists working in the field under time constraints.

**Age-at-Death Estimation**

Aspects of the os coxae and cranium are also the focus of many adult age-at-death estimation methods. More specifically, the pubic symphysis and the sacroiliac joint of the pelvic girdle are affected by regular age-related changes, and in a skeletal assemblage, the faces of the pubic symphyses and the auricular surfaces of the ilia indicate how the body has modified these joints over time. These progressive changes have been divided into stages, or phases, that provide an excellent means for comparison of skeletal remains. Likewise, the cranium is not one, but many bones that slowly fuse throughout life at junctions called cranial sutures. These sutures are often analyzed to estimate adult age at death because the degree of closure is also age-related.

If possible, physical anthropologists use more than one single method and calculate a composite age range. Certain age-at-death estimation methods, such as the Suchey-Brooks method discussed below, require knowledge of the sex of the individual. Therefore, sex should be estimated prior to age at death.

Two methods for analysis of the pubic symphysis have been widely used by biological anthropologists. The first method, published by Todd in 1920, is a numbered phase system based on a sample of 306 white male skeletons of known age. These phases were revised in 1921 to include data from African Americans and females. Though mostly accurate, Todd’s publication reveals several examples of when the
estimated age of an individual’s pubic symphysis did not match the estimated age of the rest of the skeleton or did not match the recorded age at death of the individual (Todd 1920). Consequently, Todd’s method was revised again by Brooks and Suchey in 1990, when separate standards were created for females and males. The sample group for this revision was more diverse, including individuals from a range of ancestral and socioeconomic backgrounds, as well as an age range of 14 to 99 years old (Brooks and Suchey 1990: 228). Because this collection embodies more diversity, results from the Suchey-Brooks method may carry more weight than the results from the Todd method during the construction of a final age range.

Because the auricular surface is a larger joint surface than the pubic symphysis, it has more observable, age-correlated changes and is also often better preserved in archaeological contexts. Furthermore, the auricular surface is not affected by sex or ancestry, eliminating many of the confounding factors of other aging methods (Buikstra 2015). The first method conducted for auricular surface morphology was fashioned by Lovejoy, using the Todd collection (Lovejoy et al. 1985). This method scores the surface on its overall appearance, assigning individuals to numeric stages that are correlated to precise age ranges. In 2002, Buckberry and Chamberlain revised Lovejoy’s method for auricular surface morphology, implementing a more categorized approach to scoring. Instead of one overall phase, Buckberry and Chamberlain’s method individually scores the transverse organization, surface texture, microporosity, macroporosity, and apical changes for different regions of the auricular surface. The scores are then summed to calculate a composite score with a correlated age range. Buckerry and Chamberlain (2002: 236) conclude that, “[a]lthough the age estimates
produced by our method are wider, this revised method is easier to apply and may be more reliable than that of Lovejoy et al. (1985).” However, the sample used during this study was only 180 individuals and younger ages were underrepresented (Buckberry and Chamberlain 2002).

In addition to analysis of the pubic symphysis and the auricular surface, both ectocranial and endocranial suture closures may be observed for adult age-at-death estimation. The method presented by Meindl and Lovejoy (1985) scores multiple ectocranial suture sites on degree of suture closure. Once recorded, the suture closure scores are divided into two groups, lateral-anterior and vault, and a composite score for each group is calculated. Tests on their sample population of 236 individuals indicated that, “the lateral-anterior sutures are superior to the sutures of the vault, the ectocranial is superior to endocranial observation, and age estimates are independent of race and sex” (Meindl and Lovejoy 1985: 57). In their conclusion, Meindl and Lovejoy state that although the cranial suture method is inferior to the auricular surface and revised pubic symphysis methods, if the os coxae are absent or poorly preserved, this method would suffice (Meindl and Lovejoy 1985: 65). Methods for scoring seventeen ectocranial and endocranial suture locations are provided in “Standards For Data Collection From Human Skeletal Remains” (Buikstra and Ubelaker 1994: 33-38).

Physical anthropologists may also choose to analyze other skeletal indicators of age such as the presence and progress of osteoarthritis and dental attrition. However, these skeletal changes vary among populations and are affected by multiple factors such as occupation and diet.
**Stature Estimation**

Living stature of individuals can be calculated using maximum length measurements of the tibiae and femora and the formulae provided in Trotter’s 1952 study. Although the best estimations are calculated from lengths of many long bones, Trotter noted that stature estimations based on the lower limb bones had a smaller standard of error than those made from bones of the upper limb (Trotter and Gleser 1952: 484). This stature study was conducted on black and white American men, and for the estimation of stature for individuals from another population (such as individuals from medieval European), it may be helpful to use another stature sample for means of comparison. For example, in his 2004 article, Richard Steckel provides average stature estimations for a range of locations in medieval Europe, which show an unexpected, significant increase in average height when compared to heights in the following period of industrialization (Steckel 2004). A 2005 paper by Nikola Koepke and Joerg Baten also provides stature data for individuals in medieval Europe, pooling data from 314 sites in Europe for the years 0-1800 AD (Koepke and Baten 2005). Stature estimates calculated using Trotter’s formulae can be compared to the statures provided by Steckel and Koepke and Baten for more accurate estimations of medieval European populations.
Bourgfontaine

Introduction to Bourgfontaine

Bourgfontaine was a Carthusian monastery located in northern France, formally established between 1323 and 1325 AD. Today, the only standing portions of the medieval monastic complex are the shell of the church and portions of the precinct walls surrounding the greater cloister. Other structures of the outer court also survive, as do a number of early modern buildings. Carthusian monasteries are different from other monasteries in that instead of living in a communal dormitory, the brethren each had an individual cell with a garden. The charterhouse at Bourgfontaine was no exception, though with twenty cells, it was slightly larger than a typical contemporary Carthusian monastery, which had only twelve (Bonde and Maines 2012: 629-630). One area where Bourgfontaine dramatically differs from other Carthusian monasteries is in its royal patronage. The original patron, Charles, count of Valois, was not royalty when he established the monastery. However, after his death in 1325, Charles’ son and successor, Philip, became the next founder and saw the construction of the monastery to completion. Philip was crowned first Valois king of France in 1328, and the foundation of Bourgfontaine became royal. Despite his wishes, no portion of Charles was interred at Bourgfontaine because he died during its construction. Philip, however, asked for his heart to be buried at the monastery, “perhaps echoing his father's wishes for his own” (Bonde and Maines 2013: 17). The heart tomb has not been recovered archaeologically, but iconographic, physical, and scientific evidence points to its location below the “retro-choir” structure adjacent to the church (Bonde and Maines
Beyond the heart tomb, other evidence of burial includes the human remains that were recovered from a hole in the eastern cloister alley wall during the 2015 excavation.

I. Trench 12: Cimetière

For the purpose of locating Bourgfontaine’s cemetery, one of the most helpful historical sources available was a seventeenth century painting. Close inspection of this painting shows a cluster of stones in the northeast corner of the great cloister (fig. 3.1). This feature raised suspicions of the presence of a cemetery in the great cloister, and during the 2016 excavation season, the MonArch team explored this possibility. No stones are left on the surface of the ground today, so using the painting as a guide, we estimated where the feature would have been and set a trench. Trench 12 soon earned the name “cemetery trench” because we immediately began to find human bone in densities unparalleled in other trenches on the site.

II. Methods of excavation from discovery to removal

Excavation of the cemetery area at Bourgfontaine began with the demarcation of an approximately 4 m by 4 m sounding trench located about 11 m from the eastern outer
alley wall in the northeast corner of the greater cloister. The first 50 cm of earth was
removed with a mechanical shovel, revealing a scatter of disarticulated bones. Another
50 cm were removed from a portion of the northwest half of the trench, exposing more
scattered bones. The bone scatters followed no direction or pattern, and were likely
representative of multiple individuals. Although they did not correspond to an
articulated burial, the bones presented a density of human remains much higher than
that of the other trenches on the site, leading us to believe that this region of the greater
cloister had been used as a cemetery at some point in Bourgfontaine's history.

Before progressing deeper into the trench in search of a complete burial, we
lifted the surface finds for further analysis. One of these bones was a vertically oriented
humerus, and in order to remove it completely, we needed to excavate area around it.
While working to recover the humerus, we exposed the orbit of a cranium (originally
mistaken for the obturator foramen of the os coxa). This small portion of a skull was
intriguing—the bones that fuse to form the orbit (the frontal, zygomatic, and maxilla)
were in good condition and the cranium was in a supine position (facing upwards).
Furthermore, bands of sediment with a different coloration on the surface of this layer
represented potential burial cut marks—evidence of the areas of ground that had been
cut out when the medieval grave was dug. Quite possibly, a complete skeleton rested
below the sediment. At this point, we shifted our attention away from the larger
cemetery trench and continued to excavate the section with the skull.

Quickly, we discovered the cranium was complete and in tight articulation with
the mandible. If the burial had been badly disturbed, like the other bone scatters we had
found, the cranium and mandible would have likely been separated; since they were in
such tight articulation, we became even more convinced that this excavation was leading to a complete burial. While exploring this area, more bones (a fibula, a femur, two tibiae, a clavicle, the remaining portion of the vertically oriented humerus, a scapula, and a vertebra) surrounding the superior skull were revealed at the same level (fig. 3.2). Since the skull was articulated and complete, it seemed unlikely that the surrounding bones were from that same individual, however this was not confirmed until further excavation revealed a second mandible in the westernmost part of the burial and shoulder girdles (scapula and clavicle) with articulated humerus on each side of the articulated skull. Soon, we unearthed a second cranium in the north baulk, along with other bones, increasing the number of duplicate bones contained within this burial.

As excavation continued, we could say with confidence that this grave contained two individuals—one in full articulation (now called BF-16-1) and one mainly located in the western portion of the grave (now called BF-16-2). Although many of BF-16-2’s bones were found within this grave, there was an unusual lack of smaller bones (metacarpals, metatarsals, carpals, tarsals, and phalanx) and teeth (with
the exception of one lower premolar within the mandible). BF-16-1 was more complete, and buried in a supine position (lying on the back) with the hands placed on top of one another, resting on the mid-abdomen (fig. 3.3; fig. 3.4).

Just above (west) of the hands, we discovered a “hook and eye” type metal fastener and a small textile fragment (fig. 3.5). Three other metal “eyes” were found in the area of the lower ribs. As we excavated posteriorly, we encountered trouble in that the eastern baulk covered the remainder of the BF-16-1 (from mid femur to foot). In order to access these bones, we extended the cemetery trench in the eastern direction and completed the excavation.

Before lifting BF-16-1 and BF-16-2 from the ground, we documented each bone, as well as locations of strict/loose articulation, on the designated forms. Overhead photographs were taken and used for a scaled drawing. Further photography captured important sites of bone articulation and the locations of material culture. While lifting
the bones, we took elevations for each of their lowest points. Once the bones were removed, we excavated the remainder of the burial cut, checking for other material culture or human remains, and documented the boundaries of the grave (fig. 3.6).

III. Analysis of the burial space

Some of the major questions we pondered during and after the excavation of this burial were, “How did these skeletons end up this way?”, “Why is one skeleton articulated while the other is in complete disarray?”, and “Are there any indicators on the bones suggesting they were moved by human force?” Although we will never know with certainty what happened to the two individuals, certain possibilities appear more likely than others.

For instance, one plausible explanation for the stark contrast between the two burials is that the BF-16-2 was buried prior to BF-16-1. This aspect of time would account for the difference in decomposition suggested by the complete articulation BF-16-1 and the disarticulation of BF-16-2. The skeletons of the two individuals were likely brought together at the time of BF-16-1’s burial. It seems possible that while
digging the grave for BF-16-1, BF-16-2 was disturbed and became part of the fill for the burial of BF-16-1. Equally likely, BF-16-2 may have been intentionally pushed towards the western border of the new burial cut to make room for BF-16-1. Both of these situations are conceivable—disturbance of burials in medieval cemeteries is not uncommon—however, neither situation explains why the smallest bone found in association with BF-16-2 was a talus. The smaller bones and teeth may have been misplaced in the sediment during reburial, pushed beyond the bounds of our excavation, or they may have disintegrated in the soil over time, assuming BF-16-2 predates BF-16-1. The possibility of disintegration, however, is less likely to happen to the teeth because of their highly-mineralized composition (Hillson 1996; White et al. 2012). Taking this into consideration, it is also imaginable that during the burial of BF-16-1, BF-16-2 was intentionally moved from another location and added to the grave of BF-16-2. Whoever gathered BF-16-2 for this relocation may have overlooked the smaller bones and teeth.

In accordance with each of the situations discussed above, several of BF-16-2’s bones display evidence of having been moved by human force. Beyond the apparent absence of all craniofacial bones and fragmentation of the ends of long bones (e.g. the proximal left radius had broken off), long, thin indentations were featured on two bones and a clean “cut” damaged a third. The indentations were found, in varying lengths, on the surface below the pubic symphysis on the right os coxa and below the head of the left femur (fig. 3.7; fig. 3.8). The cut was found on the left anterior portion of a thoracic vertebral body (fig. 3.9). Since they are located on the anterior surfaces of the bones,
these indentations could easily have been caused by a digging tool, such as a shovel, if BF-16-2 had originally been in a supine position similar to that of BF-16-1.

**Figure 3.7 (left) Indentation on right os coxa of BF-16-2**

**Figure 3.8 (above) Indentation on left femoral neck of BF-16-2**

**Figure 3.9 (left) Diagonal slice through vertebral body of BF-16-2**

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**IV. Skeletal analysis**

During the post-exavcation portion of this project, the bones were cleaned, inventoried and photographed again. Following the methods described in the previous section, biological sex, age at death, and stature were estimated.
BF-16-1

Sex Estimation

Morphological features observed on the os coxae and skull indicate that BF-16-1 was probably male. The shape of the greater sciatic notch and the presence of a narrow preauricular sulcus support an ambiguous sex estimation (fig. 3.10; fig. 3.11). However, the absence of features such as the subpubic concavity and the ischiopubic ramus ridge, as well as the robusticity of the mastoid processes, supraorbital margins, and the glabella are definitively male characteristics (Table 1; Table 2) (Buikstra and Ubelaker 1994).

| Table 1 Sex estimation of BF-16-1 |
|-------------------------------|---|---|
| Pelvis                        | L | R |
| Ventral Arc (1-3)*             | 3 | 3 |
| Subpubic Concavity (1-3)       | 3 | 3 |
| Ischiopubic Ramus Ridge (1-3)  | 3 | 3 |
| Greater Sciatic Notch (1-5)    | 3 | 3 |
| Preauricular Sulcus (0-4)      | 2 | 0 |
| Estimated Sex, Pelvis (0-5)    | 4, probable male |

*For tables 1, 2, 4, and 5: lower numbers in ranges (e.g. 1-3) represent more feminine traits

| Table 2 Sex estimation of BF-16-1 (cont’d) |
|-------------------------------|---|---|---|
| Skull                         | L | M | R |
| Nuchal Crest (1-5)             |   | 4 |   |
| Mastoid Process (1-5)         | 4 | 4 |   |
| Supraorbital Margin (1-5)     | 4 | 4 |   |
| Glabella (1-5)                |   | 5 |   |
| Mental Eminence (1-5)         |   | 4†|   |
|                              |   |† |   |
| Estimated Sex, Skull (0-5)    | 4, probable male |

†Mandibular resorption may distort mental eminence score

Age-at-death estimation

The right pubic symphysis of BF-16-1 has a lipped dorsal margin in addition to a partially distorted delineation around the entirety of the symphyseal face. A portion of
the dorsal margin has begun to erode, and a small amount of pitting is present on the face on the slightly depressed face. Irregular ossification is also a marked feature on this pubic symphysis. This description best fits Todd phase 10, corresponding to an age range 50+ years, and Suchey-Brooks phase 6, with an age range of 35 to 60+ years (fig. 3.10). The left pubic symphysis shows similar age-related changes including rim erosion, face depression, and microporosity. Additionally, this pubic symphysis has an irregularly ossified ventral surface. This extreme ventral rim erosion indicates Todd phase 10 and Suchey-Brooks phase 6, giving the same age ranges as the right pubic symphysis, 35 to 60+ years at death (fig. 3.11) (Buikstra and Ubelaker 1994; Suchey-Brooks 1990; Todd 1920).

Both auricular surfaces display advanced break down of marginal lipping and intense retroauricular activity in the form of multiple osteophytes of low relief. These surfaces both fall into Lovejoy’s Phase 8, corresponding to an age of 60+ years at death (Lovejoy et al. 1985). With the more quantitative scoring approach by Buckberry and Chamberlain (2002), BF-16-1 scored high for the lack of transverse organization, dense surface texture, micro- and macroporosity on both demifaces, and apical changes for both auricular surfaces. These observations led to a high composite score which corresponds to Stage VII, age range 53-92 years (fig. 3.10; fig. 3.11) (Buckberry and Chamberlain 2002; Buikstra and Ubelaker 1994).

The crania of BF-16-1 featured sutures with both significant closure and complete obliteration. The cranial suture closure age range is not precise, but it does reinforce the postcranial estimates at 30 to 60+ years of age at death (Buikstra and Ubelaker 1994; Meindl and Lovejoy 1985).
Putting all of this evidence together, BF-16-1’s age at death is estimated to be 50+ years (Table 3).

<table>
<thead>
<tr>
<th>Table 3 Age-at-death estimation of BF-16-1</th>
</tr>
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<tbody>
<tr>
<td><strong>Pubic Symphysis</strong></td>
</tr>
<tr>
<td>Todd Method (1920)</td>
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<tr>
<td>Suchey-Brooks Method (1990)</td>
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*Right pubic symphysis estimated due to PMD.

<table>
<thead>
<tr>
<th><strong>Auricular Surface</strong></th>
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<tbody>
<tr>
<td>Lovejoy et al. (1985)</td>
</tr>
<tr>
<td>Buckberry and Chamberlain (2002)</td>
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<tr>
<td>Surface Texture</td>
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<tr>
<td>Microporosity</td>
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<td>Macroporosity</td>
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<tr>
<td>Apical Changes</td>
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<tr>
<td>Composite Score</td>
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<tr>
<td>Auricular Surface Stage</td>
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</tbody>
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<table>
<thead>
<tr>
<th><strong>Suture Closure</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External Cranial Vault</strong></td>
</tr>
<tr>
<td>1. Midlambdoid</td>
</tr>
<tr>
<td>2. Lambda</td>
</tr>
<tr>
<td>3. Obelion</td>
</tr>
<tr>
<td>4. Anterior Sagittal</td>
</tr>
<tr>
<td>5. Bregma</td>
</tr>
<tr>
<td>6. Midcoronal</td>
</tr>
<tr>
<td>7. Pterion</td>
</tr>
<tr>
<td>8. Sphenofrontal</td>
</tr>
<tr>
<td>9. Inferior Sphenotemporal</td>
</tr>
<tr>
<td>10. Superior Sphenotemporal</td>
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<table>
<thead>
<tr>
<th><strong>Palate</strong></th>
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<tbody>
<tr>
<td>11. Incisive</td>
</tr>
<tr>
<td>12. Anterior Median Palatine</td>
</tr>
<tr>
<td>13. Posterior Median Palatine</td>
</tr>
<tr>
<td>14. Transverse Palatine</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Vault Sites</strong></th>
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</thead>
<tbody>
<tr>
<td>1. Comp. Score</td>
</tr>
<tr>
<td><strong>Lat-Ant Sites</strong></td>
</tr>
<tr>
<td>1. Comp. Score</td>
</tr>
</tbody>
</table>

*Suture closure scale: 1 = minimal closure, 2 = significant closure, 3 = complete obliteration*
Unfortunately, many of the diagnostic morphological characteristics of BF-16-2 are fragmented or unclear because of poor preservation. No craniofacial bones were recovered, the majority of the left auricular surface has been broken off, and the left pubis is missing entirely.

BF-16-2

Un fortunately, many of the diagnostic morphological characteristics of BF-16-2 are fragmented or unclear because of poor preservation. No craniofacial bones were recovered, the majority of the left auricular surface has been broken off, and the left pubis is missing entirely.
Sex Estimation

The right pubis of BF-16-2 does not have a well-defined ventral ridge or ischiopubic ramus ridge and the subpubic region is not concave. Furthermore, BF-16-2 lacks preauricular sulci on both ilia and the greater sciatic notch on both sides is narrow (fig. 3.12). Morphological characteristics of the skull were estimated with extreme reservations because of the incomplete nature of the cranium. The nuchal crest, supraorbital margins, and glabella all seemed fairly pronounced, while the mental eminence was small. This inconsistency may be related to the amount of mandibular resorption on this individual. All of the present features indicate that BF-16-2 is probably male (Table 4; Table 5) (Buikstra and Ubelaker 1994).

<table>
<thead>
<tr>
<th>Table 4 Sex estimation of BF-16-2</th>
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<tbody>
<tr>
<td>Pelvis</td>
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<tr>
<td>Ventral Arc (1-3)</td>
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<tr>
<td>Subpubic Concavity (1-3)</td>
</tr>
<tr>
<td>Ischiopubic Ramus Ridge (1-3)</td>
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<td>Greater Sciatic Notch (1-5)</td>
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<td>Preauricular Sulcus (0-4)</td>
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<tr>
<td>Estimated Sex, Pelvis (0-5)</td>
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<table>
<thead>
<tr>
<th>Table 5 Sex estimation of BF-16-2 (cont’d)</th>
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</thead>
<tbody>
<tr>
<td>Skull</td>
</tr>
<tr>
<td>Nuchal Crest (1-5)</td>
</tr>
<tr>
<td>Mastoid Process (1-5)</td>
</tr>
<tr>
<td>Supraorbital Margin (1-5)</td>
</tr>
<tr>
<td>Glabella (1-5)</td>
</tr>
<tr>
<td>Mental Eminence (1-5)</td>
</tr>
</tbody>
</table>

*Estimate because of lack of facial bones inferior to frontal
**Likely distorted because of huge amount of mandible resorption

| Estimated Sex, Skull (0-5) | 4, probable male |
**Age-at-death estimation**

Postmortem damage badly affected the right pubis of BF-16-2, and therefore the Todd (1920) and Suchey-Brooks (1990) estimates will not outweigh estimates of the auricular surfaces in the final age range. There appears to be erosion of the ventral margin and the visible portions of the symphyseal face lack any signs of youthful ridges and furrows. This pubis scores between Todd Phases 8-10, age range 40-50+ years, and Suchey-Brooks Phases 5 and 6, age range 27-60+ years (Buikstra and Ubelaker 1994; Suchey-Brooks 1990; Todd 1920).

The right auricular surface of BF-16-2 provides better detail for analysis. Destruction of marginal lipping, macroporosity on inferior demiface, and the absence of any youthful criteria (e.g. transverse billowing) are indicative of an older age. The moderate retroauricular activity, with multiple osteophytes of low relief and two larger osteophytes adjacent to the superior demiface, also supports an older age estimate. BF-16-2 is placed into Lovejoy’s Phase 8, 60+ years (Lovejoy et al. 1985). The Buckberry and Chamberlain (2002) method, also indicates BF-16-2 was of old age at death, falling into Stage VII with the age range 53-92 years. With this method, the lack of transverse organization and presence of dense bone were scored, as well as the significant changes to the apex. Micro- and macroporosity were only present on one demiface, but the lower scores for these criteria did not reduce the overall age range (fig. 3.12) (Buckberry and Chamberlain 2002; Buikstra and Ubelaker 1994).

Cranial sutures were not scored because the temporal and sphenoid bones had been broken off and not all scores could be recorded. The sutures present on the superior portion of the cranial cap, such as the bregma, anterior sagittal, and obelion,
appear to be obliterated, corresponding to an old age at death (Buikstra and Ubelaker 1994; Meindl and Lovejoy 1985).

Altogether, BF-16-2’s age at death is estimated to be 60+ years. Although the diagnostic bones were in worse condition than those of BF-16-1, the observable features appear much older (Table 6).

<table>
<thead>
<tr>
<th>Table 6 Age-at-death estimation of BF-16-2</th>
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<tbody>
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<td>Pubic Symphysis</td>
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<td>Auricular Surface Stage</td>
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95
V. Paleopathological analysis

**BF-16-1**

Paleopathological analysis of BF-16-1 and BF-16-2 began with an overall inventory of irregularities of the bones. During excavation, it was immediately apparent that BF-16-1 suffered severely from multiple dental pathologies.

The upper jaw of BF-16-1 holds eight full teeth (the third molars through the second premolars on each side) and only the roots of each side’s first premolar. All upper incisors and both canines were lost antemortem, evidenced by the resorption of the alveoli (tooth sockets) in the alveolar process of the maxillae. The reactive bone invading the alveoli has produced a band of rough bone running along the front dental arch. The front teeth may have been lost due to infection, extreme dental attrition, or injury, but whatever the cause, it likely happened long before this individual died because the bone had time to react and repair. The lower jaw also displays evidence of antemortem tooth loss, but mainly in the back of the jaw instead of the front. The mandible holds the left second incisor, both canines, and the roots of the right first premolar. The other incisors, other premolars, and all the molars were lost before the time of death and the reactive bone has filled in their respective alveolus. Unlike the upper jaw, two of these alveoli, likely that of the left lower third molar and the right lower second
premolar, were healing at the time of death, leaving ovular, porous lesions on their respective alveolar portions of the mandible (fig. 3.13). There appears to be the beginning of a cavity forming on the lower right canine, at the meeting of the crown and the root.

Despite the occurrence of antemortem tooth loss, the remaining teeth show evidence of having done much chewing earlier in life through their degree of dental attrition. The cusps of the upper second premolars of both sides and of the right upper first and second molars have been worn down to flatness, exposing dentin beneath the enamel. The upper third molars do not show attrition because the left is angled slightly posteriorly the right is impacted (not fully erupted from its alveolus). The lower left first incisor also shows slight wear, exposing the dentin underneath the enamel.

BF-16-1 accumulated a fair amount of dental calculus during life, likely more than what has remained on the skeleton for analysis. The dental calculus of the upper left first and second molars is so extreme it has bound the two teeth together, making the separate teeth almost unidentifiable (fig. 3.14). A potential explanation for the severity of calculus in this location, especially the build-up on the occlusal surfaces, is that these two teeth were no longer used for mastication because of the loss of the lower left first and second molars. If the teeth had been used for mastication, it’s likely that the plaque accumulating on the occlusal surfaces would have been worn down daily, restricting calculus formation to the buccal and lingual sides of the teeth. Potentially in response to the thick calculus formation, the alveolar structures of the maxillae have receded significantly, revealing the majority of the roots of the remaining teeth (fig. 3.15). The lower teeth also show calculus accumulation on both canines and the medial
aspect of the left first incisor. This was likely one of many causes of the recession of BF-16-1’s lower alveolar structures.

In addition to dental pathologies, BF-16-1 also suffered from degenerative joint disease. The sternum was not fully recovered due to poor preservation, but it appears to have been affected by osteoarthritis at many of the costal notches (where the connective tissues of the ribs articulate). The sternal end of the first rib shows destruction of its margins as well as the growth of small osteophytes (fig. 3.16). Furthermore, the sternal ends of both clavicles and the clavicular notches of the manubrium appear osteoarthritic (fig. 3.17). These locations are entirely covered in porous reactive bone, with bone growth expanding past the typical margins of the joint surfaces. The joints of the sternum are not the joints most commonly affected by osteoarthritis, suggesting something atypical caused this ailment in BF-16-1. One possible explanation is that BF-16-1 extensively used or bore weight on the shoulder joints, increasing the load on the sternoclavicular joints. If this were the case, however,
it seems logical that BF-16-1 would show equally as severe osteoarthritis in the shoulder joint, which is not true. Another potential cause for arthritis of the sternum and manubrium is injury. If BF-16-1 had fallen in a way that disrupted the connective tissues between the sternum and manubrium, the body may have responded to the stress by laying down reactive bone at these joint sites. The hip joints also show evidence of osteoarthritic activity, with the slight destruction of the acetabular margins. Unlike the sternoclavicular joints, the hip joints are commonly affected by osteoarthritis, and although there are many causes of osteoarthritis, it is possible BF-16-1 began to experience the degenerative disease at this location simply because he was an older individual.

Moving beyond the joint surfaces, the shafts of many long bones show widespread, bilateral periostitis, leaving a rough outer layer of woven bone, instead of the typical smooth cortical bone. The rampant presence of this reaction is indicative of a systemic infection, causing inflammation of the periosteum and subsequent boney reaction. The upper limbs seem to have been most severely affected, especially the humeri where the entire length of each shaft is covered in reactive bone (fig. 3.18). Healing appears to have occurred on much of the area affected, making it unlikely that the individual died from this infection. There is also a lesion on the left distal tibia that shows periosteal response. However, because it is unilateral in nature, it is likely a reaction to a different stimulus than the systemic infection (fig. 3.19).

Areas of muscle insertion on the shafts of long bones are generally spared from the effects of infection because they are protected by the muscle’s tendon, however, this does not mean insertion sites cannot show irregularities. For example, the ulnar
Figure 3.16 (left) Osteophytes on sternal end of first rib of BF-16-1

Figure 3.17 (center) Woven bone on the sternoclavicular joint surfaces of BF-16-1

Figure 3.18 (bottom left) Periosteal reaction on both humeri of BF-16-1

Figure 3.19 (bottom right) Healing lesion on distal tibia of BF-16-1
tuberosities of both ulnae have a slightly porous appearance and look as though they have been extensively remodeled by reactive bone. The brachialis muscle insert here, meaning this area of the ulnae would not have been subject to the periosteal reaction of the systemic infection discussed above. However, overuse of this muscle, through repeated flexion of the elbow joint, may have put usually high amounts of stress on the tendon and therefore on the bone, causing the bone to remodel.

**BF-16-2**

Like BF-16-1, BF-16-2 displayed significant alveolar resorption of the mandible (fig. 3.20). The only tooth belonging to BF-16-2 that was recovered during excavation is a left second premolar still in its alveolus within the mandible. Sockets for the other three premolars, the canines, and three of the incisors are clearly defined on the mandible. It appears one of the incisors was lost during life, and since then, the bone had reacted to fill the socket. This seems to have been the case with all six molars, as well. The only evidence of a prior molar within the mandible is a region of healing bone on the left posterior alveolar portion (fig. 3.21). The single premolar shows dental attrition, which has led to the erosion of the cusps of the crown and the exposure dentin. The other teeth that fell out of the mandible postmortem likely showed similar patterns of wear.

Evidence of osteoarthritis in this individual is present on the lumbar vertebrae. Two vertebrae feature moderate lipping of the vertebral bodies, and one of the two also displays osteophytic growth on the anterior portion of the vertebral body (fig. 3.22). If more vertebrae had been recovered, it’s likely that they, too, would show signs of osteoarthritis, especially in the lumbar region.
Another significant irregularity is present on the shaft of BF-16-2’s left tibia. In comparison to the right side, the superior portion of the left shaft appears enlarged or swollen (fig. 3.23). This is likely due to a periosteal reaction to injury or infection. If infection was the cause, the unilateral nature of the reaction suggests it was localized and not systemic.

Beyond the morphological skeletal examination, ancient DNA (aDNA) analysis could reveal other pathologies these two individuals had suffered from. As stated above, Bourgfontaine was established in the 1320s, and because BF-16-1 and BF-16-2 were likely buried after this establishment date, there is a possibility that either of these individuals had witnessed the morbidity of Europe’s Black Plague. If the plague had killed them, there would be no revealing evidence on the skeletons; however, aDNA analysis could confirm or deny this possibility. (See case studies in Infectious Disease section.)
Figure 3.20 Mandibular resorption on BF-16-2

Figure 3.21 (above) Remodeling alveolus on mandible of BF-16-2

Figure 3.22 (left) Osteophyte on anterior vertebral body of BF-16-2

Figure 3.23 (below) Unilateral bone reaction on left tibia of BF-16-2
Preuilly Abbey

Introduction to Preuilly Abbey

Preuilly Abbey was a Cistercian monastery located in Égligny, France. Founded in 1118 AD, the ruins of the church, chapter house, and medieval grange, as well as elements of the medieval water system, survive to this day. The estate has been in private hands since the 1850s, and the current family house is an early-modern renovation of the medieval cloister (De Maillé 1930).

I. Chapter room burial

During the 2016 excavation of Preuilly Abbey, our team worked in a 2.5 by 5.6 m trench (Trench SC-2016) in the ruins of the medieval chapter room. On the surface of the western quarter of this trench, we discovered an oval area of a different color sediment on the surface. Excavation of this feature yielded waste materials, primarily tile and mortar fragments—it appeared to be the remnants of a trash pit. As we continued to excavate below this area, we soon found evidence of a second pit, one with different boundaries and less fragmented tile and mortar. Exploration of the second feature soon led to an even more exciting discovery—a human cranium. Following the bounds of the second pit, further excavation revealed more bones, representing what was then labeled “Burial 1,” and a series of metal pieces. The presence of Burial 1, though surprising to find during the excavation of a presumed trash pit, was not entirely unexpected in this trench. Records from the 1860s describe a prior excavation of the chapter room which had uncovered eight burials in the east
end of the space. Burial 1, however, is on the opposite end of the chapter room and in close proximity to the entrance of the room to the west (fig. 3.24). This burial location is unique because of its seemingly direct relationship to the entrance to the chapter room (see below). The complete disarticulation of the skeleton is also intriguing because it suggests the body of the individual residing within the grave had entirely decomposed prior to being buried in this final resting place. The organization of the bones within Burial 1 implies the involvement of an outside party in both disarticulation and rearrangement of the skeleton.

Figure 3.24 Plan of Trench SC-2016 in the chapter room at Preuilly Abbey
II. Methods of excavation from discovery to removal

Burial 1 was found just below layer 22 of Trench SC-2016, which contained the trash pit contents (mainly debris). Once the burial was found, the sediment inside this second pit was labeled layer 23. We discovered the cranium first, in the western limit of the feature. Following the cut marks of the pit, we excavated further and revealed more disarticulated bones, eastward of the skull. As we reached the bottom limit of the pit, an almost complete, disarticulated skeleton was revealed. Additionally, along the borders of the cut we found a set of twenty-five nails and three larger metal pieces that resembled large staples. Adjacent to one of these “staples” we found a small piece of wood. This series of nails and metal pieces, the presence of wood, and the very rectilinear nature of the burial cut altogether suggest that the bones had been buried in a wooden box. Within this box, the bones were positioned with the cranium in the west end, the long bones in the center running parallel to the west/east plane, the os coxae placed on top of one another in the east end, and other smaller bones scattered throughout (fig. 3.25). The container in question, with its shape and constraints, could never have held a fully articulated individual, and the organization of the deposit is clearly secondary in nature. Furthermore, the presence of a third pubis bone indicates the burial holds the remains of two separate individuals. The two pubis bones associated with other fragments of full os coxae are likely those of the first individual (PA-16-1), and the third pubis (PA-16-2) accidentally added to this burial while the first individual’s bones were collected.

Once all of the bones in Burial 1 were exposed, we began recording of the burial with physical anthropology forms and photography. We also drew the bones in situ,
tracing over an overhead photograph. Detail photographs were taken of many burial elements, such as bones that were too fragile to successfully lift from the ground and the precise locations of the metal artifacts. Next, we carefully lifted the bones from the burial, taking the lowermost elevations for each bone, confirming and noting identification and lateralization of each item present on the designated forms. Significant portions of many of the bones were lost at this time due to poor preservation, thus underscoring the importance of thorough and meticulous written and photographic recording. Upon lifting the bones and excavating the sediment surrounding them, the boundaries of the pit, which we had confirmed were burial cuts, became much clearer, vividly demarcating a rectangular burial space (fig. 3.26). The final dimensions of the burial were 90 cm long, 32 cm wide, and 39 cm deep. A final drawing, based upon field notes, the in situ drawing and vertical photography, was later produced using Adobe Illustrator (fig. 3.27).

All of the material culture from Burial 1, including the 25 nails and other metal pieces, were cleaned, photographed and drawn. An analysis of material, typology, and function will be completed later.

**III. Analysis of the burial space**

With close analysis of the organization of the bones within the burial and the burial container itself, we inferred certain aspects of the burial process. Based on the arrangement of the bones and their disarticulated nature, as well as the evidence for their placement within a container adapted specifically to their dimensions, we can confidently posit the intentionality and secondary nature of the deposition of this
Figure 3.25 (left) *Overhead view of Burial 1 at Preuilly Abbey*

Figure 3.26 (below) *Excavated burial cut of Burial 1 at Preuilly Abbey*

Figure 3.27 *Illustration of Burial 1. Note the placement of the nails surrounding the bones.*
individual, but the significance of arranging the bones in this way is unclear. The placement of the bones shows no evidence of anatomical coherence—limbs are not grouped together, there does not seem to be a pattern in the alignment of proximal and distal ends of long bones, etc. However, the placement of the cranium in the west end of the burial is common practice for Christian burials, such as we saw in the burial at Bourgfontaine. This tradition is based on the idea that upon resurrection the individual should rise and face eastward. Although this was a secondary burial, and there was no opportunity for a full articulated skeleton to be oriented to face east, it seems this burial process still required much thought and care. It is possible, then, that the cranium was placed in the west for the same reasons full corpses are laid with their heads in the west. Beyond following this custom, the other bones may have been placed simply in the way they best fit the container.

Additionally, analysis of how the bones settled in this box over time, shifting slightly to the northern border, gives us insight into the space within the burial container. This collection of bones on the northern border creates a rectilinear effect within the burial space, aligning with, and reinforcing, the rectangular outline of the burial cut. It also suggests movement (rolling or sliding) of the bones in the box to this northern side, indicating there was space for movement in the container.

Unfortunately, as for how PA-16-1 was prepared for this final resting place, we are reduced to supposition and imagination. One possibility, is that the individual was initially buried in a cemetery, given time to naturally decompose, and then exhumed and re-deposited within the entryway to the chapter room. This idea may explain the presence of the third pubis bone found within Burial 1. It seems very plausible that if
the first individual was disinterred from a cemetery, a piece of a different burial nearby could have accidentally been gathered. Medieval Christian cemeteries are characterized by dense and often overlapping burials, as well as for reuse of burial space, with little or no regard for the previous inhabitant. It is also well known that bones of an original burial were often regrouped to make room for a subsequent tenant, moved to a charnel pit or ossuary, or simply tossed to the side. In this scenario, a mixing of individuals seems almost inevitable. However, the reburial of PA-16-1 within the chapter room, which holds great significance as a burial zone, suggests the individual was not originally buried in the monastic cemetery. It seems more likely that PA-16-1 was first buried in another significant burial area such as the church or eastern cloister alley. If this were true, PA-16-1 may have needed to be moved because the burial had been accidentally disturbed during construction. Following the typical mode of growth of Cistercian monasteries, Preuilly Abbey likely underwent a phase of significant renovation dedicated to replacing the original wooden monastic buildings with new stone editions. This type of construction would have included the church, potentially disturbing burials beneath the floorboards. In medieval Christianity, churches often became the burial sites of important figures, such as bishops or abbots. If the original burial of PA-16-1 had been disrupted within the church and the skeleton needed to be relocated, it seems appropriate that those responsible would have chosen another place of significance, such as the chapter room, for a secondary interment (O’Sullivan 2013: 271). Preuilly Abbey also features a burial in a stone sarcophagus tucked into a niche in the walls just outside the church. There were likely other burials like this, and
disturbance of one of them could have prompted a secondary burial within the chapter room as well.

Another possible reason for this burial arrangement is that PA-16-1 was treated with the German burial practice *mos teutonicus*. During this process, the corpse is disemboweled, divided into workable pieces, and boiled in water, wine, or vinegar to remove the flesh from the bones. The bones are then subsequently gathered and wrapped in an animal hide until they are buried (Brown 1981: 221; O’Sullivan 2013: 265). Typically, this process was only used to prevent a corpse from putrefying when death occurred far from the desired burial place or burial was delayed for other reasons, as might have been the case for Crusaders, for example (Weiss-Krejci 2001: 771). The presence of the second individual neither supports nor refutes this possibility. Although it seems unlikely, one could imagine if *mos teutonicus* or a similar methodology was employed, that the second individual’s pubis might have been a remained within whatever receptacle was devoted to the practice, and therefore became mixed in at this point.

Further analysis of the bones supports the idea that PA-16-1 was originally buried before being relocated to the chapter room. Not only do the bones show no evidence of corpse division performed in *mos teutonicus*, such as cut marks at the shoulders and hip joints, they also do not show the effects of having been boiled, such as color change or “pot polish” (Lewis 2008: 116; Trujillo-Mederos 2016: 699; White et al. 2012: 47). Many of the bones do, however, show slight erosion on their posterior faces (fig. 3. ). This may have been caused during the decomposition of a corpse laying in a supine position. Furthermore, the majority of small bones were absent from Burial
1, which may have happened during a relocation event. However, as preservation was poor in this burial, it is also possible that the smaller bones were present and had disintegrated to a point where they were no longer identifiable at the time of excavation.

These two examples, however complex they may be, serve the purpose of underscoring how little we may determine about the events prior to the secondary burial in the space where PA-16-1 came to finally reside. What is clear is that the space PA-16-1 occupies is unique and distinct in nature, though the exact meaning of this may escape us. In conclusion, Burial 1 resides within the larger context of a space in which a total of eight other burials, including one double burial, were found in the 1860s. Further excavation could confirm or disprove the presence of these burials, provide insight into the methods used during this nineteenth century excavation, and reveal whether the material was removed and studied or merely revealed and left in situ. Further exploration could also yield other, undisturbed burials elsewhere in the chapter room. Textual research is underway on obituaries from the monastery, but as of now, the burials remain unidentified.

IV. Skeletal analysis

Preservation was very poor, resulting in the fragmentation of number of the bones from Burial 1. Following their extraction, the bones that were solid enough were carefully cleaned and photographed. Unfortunately, the os coxae (as well as the parts of the cranium that might be useful for a secondary sex estimation) were not preserved well enough for accurate analysis of age or of sex. It is more likely that both PA-16-1 and PA-16-2 are male because the majority of people buried at monasteries are men,
although there are, of course, exceptions to this, in the cases of female patrons and royalty, for example. The pubic symphyses of PA-16-1 offer some indication of an estimated age at death, as does the only bone, also a pubis, from PA-16-2.

**PA-16-1**

**Age-at-death estimation**

The pubic symphyses of PA-16-1 both show a clear delineation of the inferior portions of the symphyseal faces, but also feature remnants of ridges and furrows. These characteristics corresponded with Todd’s Phase 8, and an age range of 30-45 years (Todd 1920). Because sex was not estimated, the Suchey-Brooks method was taken as secondary to the Todd method. The features noted above place PA-16-1 into Phase 4, age range around 25-60+ years (combined female and male range) (Buikstra and Ubelaker 1994; Suchey-Brooks 1990; Todd 1920).

Endocranial and ectocranial sutures were also examined, but not enough were present on the fragmented crania to calculate composite scores with the Meindl and Lovejoy (1985) method. The endocranial sagittal, left lambdoid, and left coronal sutures, as well as some ectocranial sutures, were completely obliterated, while sutures such as the ectocranial midlambdoid were significantly closed. These observations correspond to a middle to older age-at-death estimate (Table 7).

<table>
<thead>
<tr>
<th>Table 7 Age at death estimation of PA-16-1</th>
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<tbody>
<tr>
<td>Pubic Symphysis</td>
</tr>
<tr>
<td>Todd Method (1920)</td>
</tr>
<tr>
<td>Suchey-Brooks Method (1990)</td>
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</tbody>
</table>
Stature estimation

The living stature of PA-16-1 was estimated using the maximum length of the left femur and tibia and equations provided in Trotter and Gleser (1952). During life, PA-16-1 was likely between 167 and 174 cm. tall. This range includes the average height for men in northern Europe during the Middle Ages (Steckel 2004) (Table 8).

<table>
<thead>
<tr>
<th>Table 8 Stature estimation of PA-16-1</th>
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<tbody>
<tr>
<td><strong>Bone</strong></td>
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<tr>
<td>L. Femur (bicondylar length)</td>
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<tr>
<td>L. Tibia (maximum length)</td>
</tr>
<tr>
<td>Combined femur/tibia equations</td>
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PA-16-2

Age-at-death estimation

The pubic symphysis of PA-16-2 shows erosion of the margins and pitting, suggesting a significantly more advanced age at death. PA-16-2 is placed into Todd Phase 10, age range 50+ years, and Suchey-Brooks Phase 6, age range 35-60+ years (combined female and male range) (Table 9) (Buikstra and Ubelaker 1994; Suchey-Brooks 1990; Todd 1920).

<table>
<thead>
<tr>
<th>Table 9 Age-at-death estimation of PA-16-1</th>
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<tr>
<td><strong>Pubic Symphysis</strong></td>
</tr>
<tr>
<td>Todd Method (1920)</td>
</tr>
<tr>
<td>Suchey-Brooks Method (1990)</td>
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</tbody>
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V. Paleopathological analysis

The paleopathological analysis of PA-16-1 was hindered by the poor preservation of the secondary burial. Many bones were fragmented and unobservable after they were lifted from the ground. Working around this obstacle, varied pathologies were still identified and analyzed.

Due to the nature of this burial, very few teeth were recovered in their sockets, but through identification, some of the teeth were able to be placed back in their respective jaws to recreate PA-16-1’s dentition. There is postmortem damage to the upper jaw, but from the available portions it is clear this individual died with many teeth in place. Both canines, two premolars, and one molar of the upper jaw were recovered, but the number of empty alveoli in the maxillae suggest the individual had died with even more teeth in place. Among the sockets, there is also evidence of antemortem tooth loss, both in the regions of the left incisors and the left molars. On the left alveolar portion of the left maxilla, the reactive bone filling a socket was interrupted by the opening of an abscess. Although this abscess is near where the alveolus for the third molar would have been, it is clear that this feature is an abscess and not an alveolus because its borders are not as clearly defined as those of an alveolus (fig. 3.28). Other abscesses are found in the superior portion of the canine jugum (above the socket that would have held the canine) and in the anterior portion of the right palate (fig. 3.29). The incisive foramen, also located on the anterior palate, is typically only a channel for blood vessels and nerves. However, in this individual, it looks as though the incisive foramen has been widely expanded, potentially also acting as an outlet for pus that had been building up within the bone. The sheer number of abscesses found in
the upper jaw suggests the infection of the mouth was rampant. Furthermore, these abscesses show no signs of healing and were likely active at the time of PA-16-1’s death. Resorption of the alveolar portion in certain areas of the maxillae, such as near the abscess in the canine jugum, suggests this infection may have been periodontal disease.

**Figure 3.28** Abscesses on the maxillae of PA-16-1

**Figure 3.29** Abscess on the canine jugum of PA-16-1

**Figure 3.30** Varied patterns of wear on the upper dentition of PA-16-1. From the left: two canines, two premolars, and one molar
It is also important to note that the teeth of the upper jaw show varied types of wear. For example, both canines show wear in a superior-posterior diagonal direction, leading to the complete destruction of their lingual surfaces and exposure of the pulp cavity. One of these two canines was also affected by a carious lesion, which likely expedited the wear process. In contrast, the molar displays planar occlusal wear (fig. 3.30).

The lower jaw is also in a fragmented state due to postmortem damage, however, seven teeth were able to be reassigned to this bone—an incisor, two canines, two premolars, and two molars. The alveoli for other incisors have been remodeled by reactive bone, as well as the alveoli for the left lower dentition posterior to the first premolar (the right side likely held both molars, but the mandible is broken) (fig. 3.31). These teeth also show multiple different patterns of dental wear. For example, the lingual surface of the incisor, which is typically shovel-shaped, has been worn vertically. The lingual surface is now entirely planar from the tip of the crown to the cervix. This attrition is much different than the bidirectional wear on the left premolar, which has shaped it

Figure 3.31 Mandible of PA-16-1. Note the resorption of alveoli on the left and the varied patterns of tooth wear.
into a slight point, and the “cupping” wear on the canines and first molar.

The post cranial skeleton also shows signs of pathology. The right clavicle shows arthritic reaction on the articular surface for the manubrium, suggesting abnormal stress on the right sternoclavicular joint. This reaction appears both additive and destructive, with the formation of small osteophytes as well as micro- and macroporosity. Without the remnants of the manubrium, it is impossible to know if this reaction was isolated to the articular surface of this clavicle. The inferior sternum was recovered, however, and its right fifth costal facet shows ossification of the cartilage attaching the ribs to the bone. This ossification event is likely due to old age and not increased stress on the costal notches of the sternum.

The long bones of the lower limbs also show pathology, seemingly the effects of localized infections. For example, the left fibula bears a healing lesion around the mid-shaft. At about 3 cm in length, this lesion appears to be osteomyolitic in nature, instead of periosteal (fig. 3.32). This is because the reparative nature of the lesion appears to be filling in a hole (cloacae) that formed in the shaft, instead of incorporating newly formed bone into the compact bone of the shaft.

![Figure 3.32 Healing lesion on left fibula of PA-16-1](image-url)
Chapter Four: Paleopathological Interpretations

"[I]t is for the paleopathologist to elucidate the biology of specific diseases in early people, and it is for the archaeologist and social historian to elucidate the associated environmental factors." (Manchester 1984: 162)

A departure from “science”

Through paleopathological examination, paleopathologists can identify skeletal irregularities and produce differential diagnoses for the individuals in question. This process in isolation is possible for any skeletal sample size. The processes of analysis and interpretation, however, are more number dependent. Aside from case studies identifying a single incidence of an unusual disease, paleopathological analyses are generally performed on large collections of skeletal remains and include statistics that address disease prevalence, distribution between sexes, and other broad conclusions. For example, the published findings of the archaeological investigation of the St. Mary Spital Hospital in East London includes the osteological analysis and interpretation of 5,387 individuals (Connel et al. 2012). The statistically significant conclusions reached in studies of this size are vital to our understanding of past health, however, the methods are somewhat limiting through their dependency on math and science.

In addition to the technical problems, Sofaer (2006) identifies another issue with taking an exclusively scientific approach to paleopathology. Within the field of bioarchaeology, data is gathered from the remains of humans from another time and place and interpreted through our current-day, westernized scientific lens. This
scientific approach to bioarchaeology has influenced the clinical interpretation of paleopathology of human remains and has led to questions about why paleopathologists interpret past disease using today’s medical standards. Is there an enhanced, more contextualized, way to approach paleopathology? The answer is simple—there is.

An intriguing alternative to the scientific, population-wide focus is that of osteobiographical analysis, which is based on the idea that the skeleton can reveal a person’s life story. Scott (2017) describes osteobiographies as “a means of investigating these intersections, in particular the interrelation of age with other aspects of social identity,” with a focus on “how aspects of identity affected the individual’s pathway through life.” Even so, an exploration of social identity is unlikely the goal of paleopathologists, and this approach appears to still be guided by non-contextualized interpretations. New theoretical frameworks may be the only avenue for further analysis of a small or individualistic sample size paleopathological studies.

As briefly discussed in Chapter 1, a possible approach to individualistic archaeology is phenomenology. Both Sofaer (2006) and Johnson (2011) explain phenomenology by emphasizing the lived experience through the body’s spatial relationship with a landscape, building, or monument, making it seem almost irrelevant to paleopathological studies. Other interpretations of embodiment through a phenomenological framework explore more than spatial relationships. However, all phenomenological studies feature explorations of “sense,” a concept that has led to novel interpretations as well as issues with the approach. Sofaer (2006: 22) notes that within most phenomenological studies, “visual experience has been unduly prioritised over other forms of sensation.” This predisposition to sight is problematic for many
reasons, one being it suggests a “hierarchy” of the senses. Furthermore, when a single sense is interpreted in isolation it nullifies the “intensely synaesthetic nature of the human experience,” which is rarely shaped by one sense at a time (Hamilakis 2014: 95). To compensate for the lack of interpretations of the other four senses, more recent studies have attempted complete archaeologies of the senses as well as studies of “integrative aspects of human experience, such as emotion, memory, and identity, and/or particular corporeal experiences such as food and drink consumption, childbirth, sex, violence and welfare” (Hamilakis 2002: 5). Despite the efforts to account for all five senses, these archaeological studies are still fall short because they “operate within the Western paradigm of the five senses, even when they attempt to undermine its implicit hierarchy” (Hamilakis 2014: 95). It is therefore potentially more effective to interpret an entire experience without differentiating between how a stimulus would affect each sense separately.

When working in a field that is deeply grounded in the scientific approach, there are still reasons to be skeptical about the empirical basis of the phenomenological approach. However, because the sample size from Bourgfontaine is two and from Preuilly Abbey is one, the individualistic approach is worth pursuing. Inspired by phenomenology, one might start to ponder the conditions molding an individual’s lived disease experience. Following these thoughts, formal interpretation of this disease experience could be based upon three general guidelines. First, as developed in Chapters 2 and 3, paleopathology of the human skeleton reveals certain potential diseases an individual may have suffered during life. When exploring the effects that disease had on an individual’s life, it appears problematic that paleopathological
literature often provides information on the skeletal indicators of disease and the affected soft tissues, but very little on the symptoms resulting from those diseases. Exploring this information may not be a priority to paleopathologists completing population-wide studies, however, it is important in the consideration of the individual’s experience. Therefore, symptoms of the discussed diseases should be added to the paleopathological diagnoses for a deeper understanding of the lived experience.

Second, diagnoses and conclusions reached through paleopathological analysis should be interpreted within the context of contemporary medical standards and documentations. Disease is a lived experience, not a set of criteria that match a diagnosis, and without contextualization, paleopathological diagnoses only account for one aspect of this experience. With the current methods of paleopathology, researchers are able to observe irregularities in the skeleton, make differential diagnoses, and even confirm diagnoses with molecular studies. Characteristic symptoms to certain diseases may be added to the data available, but these conclusions are still limited to the clinical aspect of disease and say nothing about the social conditions of the disease experience. From the skeleton, paleopathologists cannot always “calculate” how or if an individual’s condition was diagnosed or treated. Likewise, we cannot “examine” how an individual would have been regarded in society (or within a community of monks) in a changed disease state. These factors must be inferred through referencing of historical documentations, such as extant medical texts, as well as anthropological and psychological studies. For example, the social condition of illness, which may be shaped by the cultural ideas of pollution, “dirt,” and unique stigmas, plays a huge role
in the overall disease experience (Douglas 1966). Furthermore, human social interactions may influence the disease experience through the occurrence of psychological effects such as the placebo (Myers and Twenge 2016).

Lastly, there are certain empathetic parallels that can be drawn through a shared human experience, such as the throbbing pain of a toothache. Sofaer (2006) shares this sentiment:

In a sense, the world can be experienced only through the body since, as body and mind cannot be separated, we have no other means of sensing it. The universality of the human body lends people common or shared experiences which can also be used to move from present to past in the interpretation of archaeology. (Sofaer 2006: 21)

Shared experience alone is not enough, leading us to the archaeological and historical explorations that guide this study.

In this section, I follow the lead of phenomenological archaeologists and attempt to further reconstruct the experiences BF-16-1, BF-16-2, and PA-16-1 may have faced in response to their disease. It should be noted that this type of interpretation depends on both the initial scientific exploration that guided Chapters 2 and 3, as well as a thorough historical documentation of the medieval period. This short chapter will briefly discuss the history of medieval medicine and explore potential experiences the individuals from Bourgfontaine and Preuilly Abbey may have faced in response to their pathological conditions.
An overview of medieval medicine

No one set of standards guided medieval European medicine. Authors of medical texts from that time period drew information from a range of sources and life experiences, formulating varied diagnostic approaches and methods of treatments. Yet, some similarities between these texts are apparent, namely the “emphasis on dietary regulation as a key to health” and certain specific dietary recommendations which were central to Hippocratic tradition and the basis of many medieval remedies (Siraisi 1990: 121). For example, to treat cancer of the mouth, “Take eight or nine leaves of sage (*Salvia officinalis*), and pound well with some salt and vinegar, apply a plaster to the part” (Anderson 2004: 420).

There is also commonality in the discussion of the four humours—blood, phlegm, yellow bile, and black bile—and the need for a balance between them within the body (Jamroziak 2013). Siraisi (1990) states the human body was thought to exist “in either health, sickness, or a neutral state between the two,” a categorization likely arising from a dichotomized focus on balance versus imbalance (Siraisi 1990: 120). Medical treatment, therefore, was as much a preventative practice of keeping the humours in balance, as it was one that treated ailments. A “preventive health regime” may have been tailored to a patient with particular recommendations for “diet, exercise, rest, environmental conditions, and psychological well-being,” though this extensively personalized approach would have only been available to wealthier citizens who could afford to visit a physician regularly. In the Cistercian order, as in many other monastic communities, blood-letting was a common practice, “considered a beneficial,
preventative measure” for keeping the four humours in equilibrium (Jamroziak 2013: 59).

Beyond the maintenance of balance among the four humours, the holistic approach of medieval medicine also advocated for balance among mental and spiritual faculties (York 2012). In addition to habitual practice, many Christians in medieval Europe would rely on their faith for cures and explanation when their physician’s treatment failed or they could not afford medical care (Anderson 2004). Strictly within the Cistercian order (most applicable to PA-16-1), sickness was thought to be sent by God as “both a punishment and a purification of sins,” and was therefore not an entirely negative condition (Jamroziak 2013: 58). The more one suffered during life, the closer that individual was to entering heaven after death. This belief is exemplified through the clergy’s opinions on two important monastic figures: “In the eyes of their fellow monks, Bernard’s and Alfred’s patient suffering under painful afflictions was one of the manifestations of their holiness and a process of purification in preparation for heaven” (Jamroziak 2013: 59). When a monk’s sickness led to death, it was looked upon as a beginning as much as an end: “Death was not the end of a monk’s life, but a beginning of the true life for which the monastic discipline was only a preparation” (Jamroziak 2013: 58). As a result, death was a religiously significant event, and at certain monasteries (e.g. Cluny), it was mandated that monks attend the deaths of their brethren (Paxton 1993: 631).

Christian imagery was also prevalent in medieval medicine. For example, in effect of Saint Augustine’s sermons, which posed Christ as the “divine healer” (Christus medicus), imagery of Christ as a healer was likely common (Jones 2006: 17).
Moreover, “certain saints were renowned for curing specific disease” (York 2012: 57). For example, “Saint Sebastian and Saint Roche were associated with plague… Saint Lazarus was associated with leprosy, Saint Agatha with breast cancer, Saint Mathurin with mental illnesses, and Saint Maur with gout” (York 2012: 57). Christianity also influenced the architecture of medieval hospitals, which like many churches, were cruciform in shape and led to the addition of chapels within hospitals for able patients to worship in (Jones 2006).

**Peter the Venerable**

A personal account from Peter the Venerable, Abbot of Cluny, describes the experiences of a French clergyman seeking medical help in the mid-twelfth century and provides some leads for the interpretation of BF-16-1, BF-16-2, and PA-16-1. These individuals from Bourgfontaine and Preuilly were likely of the same demographic as Peter—older clergymen—and probably had access to medical advising by physicians at the infirmary on the monastery grounds or through an outside practitioner. Peter’s account is only one man’s perspective, however, because all three individuals share a demographic, parallels may be drawn for interpretation. The most important aspect of how Peter’s account relates to the individuals from Chapter 3 is not the similarities of diagnosis, but instead, the similarities in livelihood through Peter’s position in society. This may reveal what older clergymen would have experienced and felt in response to disease (Siraisi 1990).

Peter suffered an attack of the “disease called catarrh,” which has the symptoms of an upper respiratory infection (e.g. a congested cough) (Siraisi 1990: 115). Voice
loss was a known consequence of catarrh and one that was particularly worrisome to Peter. Without his voice, he would be unable to celebrate the liturgy or preach. Fear of this disability drove him to seek medical advice, though it is unclear if the people Peter consulted were other monks at the Cluny infirmary or if they were from an outside practice. Upon examination, the practitioners speculated Peter’s “ill health was essentially a kind of imbalance in the body,” and that the “imbalance was located primarily in the humors; so the task of therapy was to restore them to their proper equipoise” (Siraisi 1990: 117). Peter was advised to take medicine and partake in bloodletting to improve his condition. However, as a “learned monk,” Peter knew more about the medical field than the average patient, and he did not hesitate to second guess the physician’s ability to cure his ailments. Thus, he “postponed his regular bimonthly bloodletting” and objected to the physicians’ recommendations of hot and moist remedies for the cold and moist disease from which he suffered (Siraisi 1990:115). Instead, Peter felt he should be consuming hot and dry remedies, in accordance with the Galenic theory of cure by contraries. Peter still followed some of the medical advice he received—although he expressed his doubt and disappointment in some of their suggestions. In a letter to Master Batholomeus, Peter voiced his lack of progress: “I have used the diet and medicines they recommended for almost three months already, but up to now I feel very little, indeed scarcely at all better” (Siraisi 1990: 115).

This account is particularly significant because it not only reveals the symptoms and treatments of disease, but also illuminates how members of the clergy may have reacted to disease. From it we learn that consulting a physician was a feasible response to illness, and that treatment was a process carried out over many months. Although he
seemingly interacted with the physician often, Peter did not make references to the expense of the treatments, suggesting that, like any members of the clergy likely had an easier path to medical care than the average citizen. However, as educated men, they faced a double-edged sword. Those familiar with medical texts knew when to seek medical advice, but, like Peter, they may have also realized when treatments were not effective or contradictory to medical texts they had previously read. With a deeper understanding of the field of medicine, it seems clergymen may not have been able to be as passive of patients as other members of the population. With his health on the line, this was likely an uncomfortable position for a clergyman. Peter’s account also illustrates the priorities of the clergy, which resided in the worship of God.

**An inferred reality of medieval dental pathology**

As discussed in Chapter 2, paleopathologists have found that dental conditions such as caries, calculus accumulation, and antemortem tooth loss were common in medieval Europe. For example, in a medieval population from France, almost a quarter of the teeth in an archaeological sample featured caries (Esclassan et al. 2009). This conclusion is reinforced by the high prevalence of dental pathologies found on the teeth of BF-16-1, BF-16-2, and PA-16-1.

When analyzing the teeth of archaeological specimens, paleopathologists use diagnostic terms such as dental caries, periodontal disease, and alveolar resorption to describe the disease state of the individual. This strictly clinical approach is different than what individuals in medieval Europe would have experienced in response to their dental conditions. In this section, I take the modern diagnoses I have attributed to
individuals BF-16-1, BF-16-2, and PA-16-1 and expand on them to infer some aspects of their dental disease experience in the context of medieval European dentistry. I have chosen to focus largely on the dental ailments because they are shared between the three individuals studied.

Extant twelfth through fourteenth century texts on dentistry align with the findings of paleopathologists—dental pathologies were rampant in medieval Europe. Consequently, toothache was a common complaint heard by the medieval physician (Anderson 2004). The descriptions of some medieval dentistry practices that were used to prevent and treat toothache survive in the medical treatise of the French doctor Guy de Chauliac.

Serving as a papal physician in Avignon, France, during the 1360s, Guy De Chauliac was likely a leader in the field of medicine at the time. In his treatise, Guy mentioned several precautionary measures to take in avoidance of dental problems: “[D]o not eat hot and cold food in rapid succession; do not chew hard objects such as bones; or soft things such as figs (Ficus carica) or honey based foods and avoid leeks (Allium porrum) which weaken the teeth” (Anderson 2004: 423). When toothache did occur, it was attributed to an imbalance of the four humours or “tooth worms” that could be smoked out of the mouth (Anderson 2004: 422). To treat the pain, various herbal remedies were recommended, including the use of opiates. If the pain continued, Guy de Chauliac authorized cautery of the affected area with hot oil or hot iron. Extraction of the tooth was viewed as a last resort, and the treatise offers information on extraction both by tools and by applying special powders, one of which “contained pellitory (Anacyclus pyrethum)… mulberry (Morus sp.)… caper roots (Capparis
spinosa), [and] arsenic as well as grease from a wood or a tree frog” (Anderson 2004: 423). Guy de Chauliac is one of few medieval physicians to advocate for dentistry tool use mentioning “razors (‘rasoures’); spatulae (‘spatures’), straight and curved; simple elevators (‘symple leuours’); two-branched elevators; pliers; (‘pynsounes’) several probes (‘dyuers serchours’) and curettage knives (‘schauynge knyfes’)” (Anderson 2004: 423). If tooth extraction was necessary, they were attended to by “barber-surgeons” or “tooth drawers” instead of doctors. Guy de Chauliac notes, however, that these practitioners should only be trusted if “dressed as doctors” or accompanied by a doctor (Anderson 2004: 23; York 2012). This is likely in response to regulations issued by King Philip the Fair in the early fourteenth century which stated, “No one is allowed to practice surgery… unless he has been examined and admitted by the sworn surgeons” (Jacquart 1994: 186).

In addition to the treatments for toothache, Guy addresses treatment for carious teeth, suggesting first the use an antiseptic gargle of “wine mixed with mint (Mentha sp.), sage (Salvia officinalis), pepper (Piper sp.) or pellitory (Anacyclus pyrethum),” followed by the implementation of a filling material “composed of gall nuts, pig grease, mastic, myrrh (Myrrhis odorata), sulphur, camphor, beeswax, arsenic and asafoetida and such other things” (Anderson 2004: 423). This conservative approach to the treatments of cavities, with filling instead of extracting, was a relatively recent idea at the time of Guy de Chauliac.

In a time when dental ailments were commonplace, it seems possible they may not have been interpreted as “diseases,” but rather as general consequences of living. Patients may have complained of toothache, but the caries causing the toothache may
not have been stigmatized as other infectious diseases such as the plague. The consequences of toothache and poor dental hygiene in general likely caused difficulties, but these handicaps may not have been of great concern if shared among a large percentage of the population.

All three individuals described in Chapter 3 exhibit extreme mandibular resorption on the posterior portions of the mandible, likely due to periodontal disease and/or the loss of their lower molars (fig. 4.1). The loss of the molars may have occurred in response to serious caries activity, extreme attrition, or calculus accumulation leading to periodontal disease. Caries activity specifically could have led to tooth loss through extreme dental decay or extraction by force as discussed above. Without immediate treatment, the initial symptoms of tooth sensitivity in response to these dental conditions would quickly develop in severe tooth pain. At this point, it is likely that BF-16-1, BF-16-2, or PA-16-1 visited their physician within their monastery’s infirmary or at an outside practice. It is impossible to know which remedy would have been suggested for these specific individuals, but it seems likely that an herbal remedy would be prescribed first, such as opium (*Papaver somniferum*) or “[a] concoction of lettuce leaves for a toothache” (Anderson 2004; Siraisi 1990: 121).
These treatments may have helped ease the tooth pain, but they would not have prevented the progressions of caries, attrition, or periodontal disease. As these conditions worsened, the lower molars may have begun to fall out on their own. Conversely, the monks may have returned to their physician or to a surgeon for the teeth to be extracted. If the extraction did not lead to infection, the individual may finally have been free from pain in that area of the mouth. However, there were potential consequences associated with lost dentition.

These consequences may have been most severe for BF-16-1. In addition to the posterior teeth in the lower jaw, this individual lost the anterior teeth (incisors and canines) in the upper jaw. This left BF-16-1 with no teeth to meet in occlusion during mastication, making it very difficult to chew foods. Furthermore, the loss of the anterior dentition would have affected BF-16-1’s speech. If, like Peter the Venerable, BF-16-1 was a preaching monk, his dental disease could have impeded his livelihood and connection with God. It is interesting to ponder what other factors of BF-16-1’s life would have changed in response to this issue: Was he provided a special diet at Bourgfontaine? Would he continue to eat in the refectory with the other monks? Did he take to asceticism because he was unable to eat most foods? We are left to speculation for the answers to questions like these.

**Stigmatized disease**

Less common or more lethal ailments, especially those with visible symptoms, were likely more stigmatized, potentially worsening the social conditions of the disease experience. An example of such an ailment is the systemic infection suffered by BF-
16-1. Although the disease indicators on the skeleton were hidden from the world during this individual’s life, the symptoms of a systemic infection were likely visible. Most individuals experiencing extensive infection, often by gram-negative bacteria, develop a fever, though the temperature of others drops to hypothermic levels (Ziegler et al. 1991). A fever and additional flu-like symptoms would have revealed that BF-16-1 was ill, and without antibiotics, such an infection would have been very difficult, though not impossible, to overcome. A potentially bedridden BF-16-1 was likely treated by a physician because the indicative lesions on the long bones show signs of healing and reparation.

Other examples of a stigmatized disease include leprosy and the plague (Roberts 2002: 213; Siraisi 1990). Roberts (2002: 213) suggests that leprous infection was feared by people, leading to the segregation of lepers into leprosy hospitals. However, the isolation and ostracism of lepers was likely ineffective. As Manchester (1984: 169) notes, an individual may be infected for five to ten years before experiencing symptoms, potentially transmitting the disease to others before feeling ill.

Medieval Europeans dealt with the plague in a rather different way. To preachers and moralists, the plague was attributed to “God’s displeasure with general human sinfulness” (Siraisi 1990: 129). The general population, however, blamed the recurring epidemics on “deliberate poisoning” of their Christian faith, using “this hostile fantasy as a pretext for intensified persecution of Jews during times of plague” (Siraisi 1990: 129). People with visible symptoms of the plague may have been avoided, due to a skewed but workable understanding of the principle of disease transmission: “[t]he spread of the plague was accordingly explained as a result of
corruption of the air that altered for the worst the complexion of those who breathed it” (Siraisi 1990: 128). Although they were likely shunned, plague victims were not viewed as responsible for their condition. It is even suggested that people suffering in this life would suffer less in their next life, making them more holy.

**Concluding thoughts**

Despite a century and a half of paleopathology research and the brilliant scientific advances achieved by paleopathologists around the world, there are still limitations to the conclusions that can be drawn from small samples. Many current paleopathological methods are quite useful for retrieving data from archaeological human remains and analyzing that data to understand the prevalence of past human diseases. However, these methods are limited by their statistical component which calls for a large sample number (>50). Most archaeological projects often unearth far fewer than fifty individuals, and even though skeletal analysis may yield accurate estimates of sex and age at death, deeper conclusions are often desired to answer specific archaeological questions. The work of Sofaer (2006), Hamilakis (2002), and others address these limitations and offer new approaches such as phenomenology. This thesis began with a scientific focus, but after combining modern paleopathological diagnoses, historical contextualization, and insights from a shared human experience, a hybridized approach emerged, providing a potential new avenue for paleopathological discovery.
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