Lines of Evidence used to reconstruct Patterns of Diet, Nutrition and Disease in Ancient Populations

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Researching, analyzing, and reconstructing the diet, nutrition, and diseases of ancient humans is an interdisciplinary field referred to as bioarchaeology. Bioarchaeologists use several methods to reconstruct the lives of ancient humans. Some of these methods are quantitative, such as skeletal and environmental analysis, while other methods are qualitative such as, interpreting archaeological evidence, using texts as historical reference, and comparing contemporary indigenous populations to ancient hunter-gatherers and pastoralist. Each method provides key insights into the lives of ancient people. I will discuss three of these methods, their techniques, and respective limitations. The three methods are: 1) Analyzing skeletal remains; 2) environmental analysis; 3) the use of archaeological evidence. After describing these three methodologies, I will present my opinion of the most useful. In conclusion I will discuss how these methods work together to create a holistic reconstruction of our past.

Each method uses several techniques to obtain key insights into various aspects of ancient life. Analyzing the skeleton is referred to as Osteological Analysis. Osteological Analysis, can provide age, gender, health and evidence of disease. Environmental analysis can help reconstruct ancient environments, provide dates of habitation, and possibly the types of subsistence strategies the inhabitants used. Evaluating archaeological artifacts can yield information about subsistence techniques, cultural practices, demographics, and technology used by a population. All of these methods work in concert to create a holistic picture of ancient life. Environmental analysis can isolate when people inhabited a location, archaeological artifacts provide cultural context, and skeletal analysis shows how these and other factors physically affected the population.

**Osteological Analysis**

The skeleton can provide a wealth of information about a person. Bioarchaeologist often use the skeleton to help determine age, gender, health and evidence of disease. Analyzing skeletal remains is
referred to as osteological analysis. Since skeletons are rarely found intact, bioarchaeologists use various techniques to gain lines of evidence about the deceased. The long bones and teeth can be used to determine age, health, and disease. The pelvis can be used to determine gender. Defects in the skull can be indicators of disease. Each part of the skeleton uses different techniques to extract evidence.

The long bones of the skeleton can be used to determine age because the skeleton matures at a fairly standard rate. At birth, the skeleton is partially formed and many bones are still in segments, such as the long bones. During childhood, the long bones are segmented; the far ends (epiphysis) of the bone are separate from the center shaft (diaphysis). As the child grows, these segments fuse together, making a single bone. This process is complete between 17 and 25 years of age (Larsen 2011). An age estimate can be determined based on the stage of the epiphyses.

Once the age of the person is established, stature can be estimated using the long bones. Long bone growth comparison can yield valuable information about nutrition and development. Shorter than expected long bones can be an indicator of health, environmental and/or nutritional stress. Under stressful conditions, a growing organism will either slow in growth or cease to grow (Goodman, Martin, and Armelagos 1984). The length of the long bone, however, is not the only factor that is evaluated. Goodman et al. (1984) refers to Hauss-Ashmore’s analysis of juveniles from prehistoric Sudanese Nubia, where the long bone length was maintained at the expense of cortical thickness. Cortical bone is the exterior part of the bone; it is also referred to as compact bone, which surrounds the spongy bone. Thin cortices in growing children are an indication of environmental stress. Lengthening of the bone may be maintained at the expense of cortical thickness. Therefore, it is important to evaluate both the length and cortical thickness of the long bones. The relationship between the length and thickness of the long bone (the long bone length and width curve) yields more information than evaluating the length alone.

The measurement of size and shape of long bones is among the most standard of procedures in osteological analysis. However, it has its limitations. Growth comparison is not absolute, for two
reasons; 1) there may be genetic factors that affect the shape and size of the bones, and 2)- the rate of
growth is usually in comparison to modern reference populations. The most efficient use of growth
curves involves comparisons of curves from genetically similar populations. (Goodman, Martin and
Armelagos 1984)

A long bone length and width curve can provide valuable information about development, but
the bone itself can yield valuable information about nutrition and health. Growth retarding stressors,
such as poor nutrition, will leave transverse lines (Harris lines) of dense bone visible in radiographs of
long bones. Harris lines can be produced in the skeleton by a variety of stressors, including starvation,
severe malnutrition and severe infection (Johnson 1999). Harris lines are a good indication of nutritional
stressors. However, once Harris lines are formed they may resorb and disappear. Resorption introduces
a potential source of error into analyses of Harris lines as indicators of past nutritional stress (Goodman,
Martin and Armelagos 1984). The presence of Harris lines indicates that death occurred during the
stress even or shortly thereafter, but prior to the bone resorbing. The long bones of the legs can also
indicate specific nutritional deficiencies, such as rickets. Rickets is caused by vitamin D deficiency,
characterized by imperfect calcification, softening, and distortion of the bones typically resulting in
bowed legs.

The long bones are not the only part of the skeleton that can yield valuable information about
the life of ancient humans. General skeletal and cranial deformations can be indicators of serious long
term diseases. These general stressors may be read and deciphered from skeletal lesions, providing a
means for assessing the health status and degree of functional impairment that an individual
experienced (Martin and Goodman 2002). Long term exposure to a disease can cause the body to react
by forming and/or destroying bone. Bone abnormalities manifest themselves in a particular manner.
Periosteal reactions (when the lesion is confined to the outer periosteal surface of the bone) and/or
Osteomyelitis and Osteitis (when the reaction courses throughout the bone tissue involving both
marrow and cortex) are two common manifestations of bone abnormalities. The bone formed during the disease process may be woven or immature, indicating that the disease was active at the time of death. If the bone is more mature, older, organized, lamellar bone, it indicates that the process was quiescent, or had been overcome (Roberts and Manchester 1997). Although, many diseases cause bone abnormalities, some diseases leave distinct damage. Tuberculosis leaves characteristic traces on the ribs and destroys the bodies of the lumbar vertebrae. Infections from the Treponema spirochete in yaws or syphilis can produce either local or widespread skeletal damage. Leprosy is characterized by damage to the bones of the face, fingers, and toes.

Bone abnormalities are also found in the skull. Anemia, scurvy, rickets, meningitis, nonspecific and specific osteomyelitis all cause cancellous bone substance of the skull (Schultz 2002). These cranial abnormalities are known as Porotic Hyperostosis and Cribra Orbitalia. Porotic hyperostosis is lesions of the frontal, parietal and orbital bones of the cranium. Cribra orbitalia are lesions on the superior border of the eye orbits. Both of these manifests as a widening of the spongy diploe with a corresponding thinning of the outer dense cortical bone, resulting in the appearance of a spongy surface (Goodman, Martin and Armelagos 1984). Many diseases cause abnormalities in the skull, because cranial bones are thin.

The dentition is also an important part of the skeleton. Examining the teeth can provide additional, and sometimes more reliable, information about the deceased. Teeth are the most indestructible part of the body and exhibit the least turnover of natural structure. Teeth remain unchanged for thousands of years, making them a more reliable source of evidence.

An individual’s age at death can be determined based on the development and eruption of teeth. This technique is a fairly precise indicator of age up to fifteen years of age, however, adult ages are harder to determine. Environment can also influence the rate of degeneration. Panchbhi (2011) explains the pulp cavity index as “Estimating the age of an adult can be achieved by determining the
reduction in size of the pulp cavity resulting from a secondary dentine deposition, which is proportional to the age of the individual.”.

Dental analysis also provides information about the nutritional stressors during development. The usual method of analysis involves the recording of defects on a single tooth; typically, this tooth is usually the canine. Goodman et al. have shown that the canine tooth is a particularly good choice because it is highly susceptible to stress and has a long developmental period. Nutritional stress during tooth development can present enamel hypoplasia (Goodman, Martin and Armelagos 1984). Enamel hypoplasias is a deficiency in enamel thickness. Enamel hypoplasias are visible lines, bands or pits across the tooth crown. Enamel hypoplasia is a better way of determining stress, because once enamel is formed it is not resorbed or remodeled during life. It provides a permanent and unaltered chronological record of stress during development. (Goodman, Martin and Armelagos 1984). In addition to nutritional stress and deficiencies, dental analysis can present clues about diet. High rates of dental caries are often associated with soft, sticky foods as with agricultural diets. An environmental sample can help determine the type of subsistence strategies the inhabitants were using.

Environmental Analysis

Bioarchaeologists use samples of the environment to estimate dates, ancient environmental conditions, and possible types of subsistence strategies employed by ancient populations. Anderson et al. (2007)suggests evidence sources can be put in three environmental categories: terrestrial, marine and ice-based. Terrestrial evidence is extracted from landforms, such as, glacial till, periglacial deposits, ancient soils (palaeosols), wind-blown material deposits (loess) and peat. These types of sources are very helpful in reconstructing environmental fluctuations. Anderson et al. (2007) provides the example of the Loess Plateau in north-central China, also known as the Huangtu Plateau, where studies of the alternating succession of loess and palaesols have yielded important information about the climate
changes since 2.5 million years ago. Anderson et al. (2007) explains “The palaeosol layers represent times of strengthened monsoon associated with higher summer precipitation and enhanced soil development, whereas the layer of loess indicate more arid periods associated with continental glaciation when strong northerly winds brought in great quantities of dust from the Siberian plan.” Information about environmental fluctuations can provide insight into the living conditions of the inhabitants of the Loess Plateau in north-central China. Loess/Palasol sequences are generally a reliable line of evidence; however it is not applicable in all geographic locations.

Sediment layers can be used to establish dates. Lake sediments and peats provide a continuous record of depositional changes. It is possible to estimate the age of an event by measuring the rate of sediment accumulation (Anderson, Goudie and Parker 2007). Sediment and peat cores are usually evaluated, top to bottom and along the length of the sample, for color, moisture, organic content and bulk density changes (Anderson, Goudie and Parker 2007). Evaluating sediment and peat cores can provide reliable estimates for the age of an event. However, this technique is most reliable if it is only applied to a specific location. Anderson et al. (2007) recognizes a common error with this line of evidence by noting: “Often faulty correlations were made by assuming that similar-looking stratigraphic layers in different places were formed at the same time when this is not actually the case”.

The ground is not the only source of evidence in environmental analysis. Trees can be used to determine environmental fluctuations and dating, this process is called dendrochronology. Trees provide an annual record of the ecosystem around them. Most trees produce visible rings every year. Anderson et al. (2011) explains “most trees produce visible annual rings because wood formed in the spring tends to have larger and more thin-walled cells than wood formed later in the growing season”. The thickness and color of each tree rings is directly affected by the available resources within the ecosystem (Coder 1999). Rings will usually be lighter and thinner when there are fewer resources available; this may include but is not limited to, droughts and poor soil nutrients. Sampling multiple
trees of different, but overlapping ages, yields a wider range of dates than a single tree can provide (Anderson, Goudie and Parker 2007). Dendrochronology has specific challenges. Anderson et al. (2007) points out these challenges by stating: “...differences in growth rates related to the age of trees and to local factors, as well as the fact that annual rings are not always clear and can sometimes be missing for particularly poor growth years. Large numbers of trees need to be sampled in an area to overcome these problems when developing a chronology.” Dating and ecosystem fluctuations are not the only evidence environmental analysis can yield. Environmental analysis can be used to evaluate subsistence strategies.

Environmental fluctuations can cause populations to change subsistence strategies. Larson et al. (2011) suggests Neolithic agriculture was an effect of changing climate. Recent environmental research supports this idea. Sediment analysis has been used to identify early domesticates. In the early 1980s, Piperno and colleague Deborah Pearsall began analyzing the sediments of the rain forest in Panama and Ecuador for more enduring plant remnants (Pringle 1998). They used phytoliths found in the sediment to prove hunter-gatherers were beginning to add domesticates to their diets as early as 10,000 years ago, 5000 years earlier than previously estimated (Pringle 1998). Phytoliths are microscopic silica bodies that form when plants take up silica from groundwater. As the silica gradually fills plant cell, it assumes their distinctive size and shape. Larger phytoliths are from domesticated seeds while the smaller phytoliths are from wild seeds (Pringle 1998). The use of phytoliths is an example of how environmental analysis can be used to indicate subsistence habits. Subsistence strategies can also be determined by the types of artifacts cultures leave behind.

Archaeological Artifacts

Archaeological artifacts can furnish information about culture, demographics, economy and subsistence strategies. Archaeological artifacts are the objects and materials ancient people used. Price et al. (2010) has classified archaeological artifacts as falling into three categories: 1) form—the size and
basic shape of the object; 2) technology—the characteristics of raw materials and manufacturing techniques; 3) style—the color, texture and decoration of the objects. Each of these categories adds context to the overall picture of ancient human life. The form of an artifact can provide key information about the function it had in daily life. A wide pottery vessel can be used to hold grains, water and/or wine. If the same type of pottery is made into a flat plate, its function then changes. Defining the technology of an artifact, such as a vessel, can help decipher what type of materials was kept in it. There are several common techniques used to determine the technology of an artifact. Physical and chemical analysis may provide information about the origins materials. Phosphate analysis from sites can provide proof of human inhabitants, and isotopic techniques can be used across the board (Price and Feinman 2010). The style of an artifact can be unique to a particular population and/or be decorated with iconography that represents cultural values. Pottery is particularly helpful in reconstructing the diet. Pottery preserves well and has many uses such as, cooking, storage, serving and carrying materials. The contents of the pottery can indicate what type of foods were commonly stored and consumed.

Using archaeological artifacts as a method to reconstruct the lives of ancient humans has many challenges. Interpreting archaeological artifacts is subjective, and can lead to misinterpretations of the information. In addition to misinterpretation, archaeological sites are often robbed, the artifacts are damaged or displaced, and environmental factors may effect the results some dating techniques. Archaeological artifacts can provide context in which people lived their lives, but its ability to provide quantitative evidence is limited.

**Preferred method of analysis**

Environmental analysis can only provide evidence about the changes in the environment and limited information about dietary habits of ancient humans. Archaeological artifacts provide a wider
range of evidence than environmental analysis, however the subjective nature of interpreting artifacts is imprecise.

Osteological analysis provides the most complete lines of evidence needed to reconstruct the diet, disease and nutrition of ancient humans. Skeletal analysis can be used as an indicator of age. The age estimate can be further corroborated by dental analysis. Determining age through dental analysis provides a better method of age determination because development and calcification is controlled more by genes than by environmental factors. Teeth are less susceptible to nutritional, hormonal and pathological changes, particularly in children (Panchbhi 2011). Dental analysis also provides results in determining health stressors. Skeletal and dental analysis yields evidence pertaining to pathologies.

Osteological analysis can provide additional information about diet and nutrition if used with isotopic technique. Analysis of stable carbon and nitrogen isotopes in skeletons is used to model diets, provide additional information about physiology, disease, and nutrition in ancient humans. Isotopic analysis can be used to gain additional information about diet and nutrition. This technique analyzes the ratios of the principal isotopes preserved in human bone; in effect the method reads the chemical signatures left in the body by different foods (Laurie 2013). Using isotopic analysis, trace elements such as iron, calcium, magnesium, lead, zinc, copper and strontium can be measured; providing evidence of dietary insufficiencies (Goodman, Martin and Armelagos 1984).

**Conclusion**

Archaeological artifacts, Osteological and Environmental analysis must be used together to reconstruct the diet, nutrition and disease of ancient populations. Osteological analysis can provide evidence of age, gender, nutrition and disease. Accurate age-at-death estimates are critical for interpreting the impact of pathologies on the well-being of a population (Wright and Yoder 2003). However, with osteological analysis the specimens studied are small samples of a larger population. The
issues found in the skeleton are specific to the individual and may not be representative of the whole population. Archaeological artifacts and environmental analysis produce generalized lines of evidence; this type of evidence can contribute to the reconstruction of the whole population. Archaeological artifacts can furnish evidence about the type of subsistence techniques used by a population, thus, providing the possible cause of any malnutrition found in the skeletal remains. Environmental analysis can be used to date the archaeological site. Environmental analysis can also define the ecosystems and identify the possible causes of environmental stress.

Using the methodologies I have mentioned and more can help create a holistic picture of ancient populations. However, it is important to remain flexible with interpretations of the data collected. Ecosystems, humans and cultures are, and have been, constantly changing. Using a small sample of any line of evidence can lead to an over generalization of the wonderful and dynamic thing we call life.
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