A History of Health in Europe from the Late Paleolithic Era to the Present: A Research Proposal

by

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Project Summary

This project creates three large databases, which will allow researchers to reinterpret the history of human health in Europe from the late Paleolithic era to the early twentieth century. During this period, human health and welfare were transformed enormously by the transition from foraging to farming; the rise of cities and complex forms of social and political organization; European colonization; and industrialization. With a trans-Atlantic network of collaborators, we will undertake large-scale comparative studies of the causes and health consequences of these and other dramatic changes in arrangements for work, living, and human interaction.

Most social scientists outside of anthropology are unfamiliar with the research potential of skeletal data. Yet, these data are the best single source available to scholars for measuring and analyzing very long-term trends in health, especially in preliterate cultures and in historical societies with few written records available for study. Even in populations of the modern era, skeletal data can inform the study of health. To obtain this evidence, we are building upon a similar but smaller NSF-sponsored project devoted to the Western Hemisphere. By sending M.A. and Ph.D. students to museums to collect health information from approximately 40,000 archaeological skeletons of people who lived at over 500 localities, we are creating an empirical basis for reinterpreting the health history of Europe. Following training to implement our coding manual, these graduate students will gather information for estimating age and sex, along with data on specific diseases such as tuberculosis and on several standard health indicators including height, and the presence of lesions associated with infections, dental problems, and degenerative joint disease. Project researchers will also create a second database by scouring the published and the gray literature of site reports that we estimate contain information on the average heights of 100,000 to 150,000 men and women who lived in Europe over the past 10 millennia. All raw data will be sent via the Internet to a central processing center at Ohio State University for cleaning, storage, analysis, and eventual distribution.

In collaboration with archaeologists and museum curators, the graduate students will prepare brief site reports that summarize the findings on health indicators; describe the cultural, economic, and social contexts of the sites; and provide information on the local environment in which these people lived. These last components will be enhanced substantially by the creation of a third database, containing systematically collected information about these sites from sources available in the field of climate history and from additional archaeological and historical sources. In addition, we will link the information on each collection to site-specific Geographic Information System (GIS) databases containing information on local ecology that will be corrected, where possible, for historical changes in environmental conditions. The reports will be published in a new Web-based journal devoted to the project, titled *Global Bioarchaeology*, to be edited by the PIs.

The principal investigators will widely advertise the research project at professional meetings to seek feedback on preliminary results, on specific research themes, and on potential collaborators. These activities will help pave the way to four major conferences planned for comparative study and publication. Pre-conferences will review major results in comparative perspective, define specific topics for the larger conferences, and discuss additional research collaborators. The anticipated conference themes are: (1) health, climate and habitat; (2) health and the transition to farming; (3) the social and economic causes and consequences of long-term changes in health; and (4) the health of women and children. Near the end of the project, we will create a program to assist 10 Ph.D. students in using the data for dissertations.

These data have enormous potential to address other large problems, several of which the PIs will pursue in other proposals, including (1) long-term trends in patterns of trauma and violence; (2) biological inequality; (3) aging and health; (4) health during the rise and fall of civilizations; (5) geographic patterns of health; (6) degenerative joint disease and work; (7) analysis of population genetics and migration patterns using ancient DNA, and (8) use of DNA from specific pathogens to study the co-evolution of humans and pathogenic organisms.

Project Description

C.I Introduction

Virtually all researchers are aware, at some level, of the significant processes of biocultural evolution that gave rise to modern societies over the past 10,000 years. We know that many modern problems have roots reaching deep into the human past, and that current conditions were often created by complex interdependent processes that unfolded over very long periods of time. As a result, the research of many social and medical scientists would benefit greatly from access to a very long-term historical perspective on fundamental issues relating to health and the human condition (Coatsworth, 1996; Eaton et al., 1988, 1997; Popkin, 1998; Cordain, 1999). This project creates that perspective for a very important dimension of the qualify of life (health) in Europe, which we will combine with related information for use in reinterpreting the causes and consequences of changing health along the historical path leading to modern societies.

Scholars understand the great value of comparative research using samples that incorporate diverse behavior. It is very difficult, if not impossible, to measure the importance a variable has had in shaping human action if that variable changes little (or is essentially constant) in the evidence available for study. The greater the diversity of the evidence we have about the past, the easier it is to rule out alternative interpretations that are unlikely to reflect actual events. Using a series of data sources that, standing alone would be open to many different interpretations, it is in this way possible to triangulate on what really happened. On these grounds, this project has great value for understanding the causes and consequences of the evolution of health, a fundamental aspect of the quality of life.

The diversity of human experience, and the corresponding variation in our health, has been enormous since the late Paleolithic era. These profound changes in health are highlighted by four pivotal transitions in the last 10,000 years of human history: (1) the shift from foraging to farming, (2) the rise of cities and complex polities, (3) European expansion and colonization, and (4) industrialization. Each of these global transitions had an enormous impact on health and the human condition. With the rise of farming, human population became larger and more sedentary, which resulted in crowding and the creation of conditions conducive to the spread and maintenance of infectious diseases (Cohen, 1989; Cohen and Armelagos, 1984; Smith, 1995; Larsen 1995). During and following the transition to farming, pathogenic organisms causing highly contagious diseases evolved significantly. The diversity of foods eaten also diminished, eventually resulting in the modern worldwide dependence on a handful of super-crops (maize, wheat, rice) that lack specific nutrients essential for growth and development (Cordain, 1999). Many believe that with the rise of cities, health deteriorated further as a result of crowding, inadequate sanitation, growing inequality, and conflict (Cohen, 1989; Cartwright, 1972). Although colonization offered new opportunities for the rapidly growing European population, it also led to the devastating spread of new pathogens to formerly isolated populations in areas such as in North and South America (Merbs, 1992; Larsen, 1994; Kiple and Beck, 1994; Verano and Ubelaker, 1992; Crosby, 1972; Cook, 1998). The spread of measles, smallpox, and other acute infectious diseases resulted in huge population losses throughout the world, not just in the Western Hemisphere (Crosby, 1986). Finally, the industrial age often brought new health costs, and many workers faced diets inadequate to sustain them in their hard work and heightened exposure to diseases spread at crowded places of work and living (e.g., Steckel and Floud, 1997).

Physical anthropologists and archaeologists are best equipped to provide the evidence necessary to measure very long-term health changes. Over the past century, they have excavated thousands of sites and studied hundreds of thousands of skeletons and their contexts. Because of its biological basis in the physiological processes of growth, development, and acclimatization to environmental change, the information about interactions with past environments encoded in these human remains provides a valuable comparative basis for evaluating interpretations of the past based on artifacts, documents, and other sources (Walker, 2000).

These basic sources of information on the lives and living conditions of our ancestors are often accessible, but for various historical, political, and logistic reasons have never been assembled into a truly comprehensive, detailed and coherent mosaic that adequately depicts the evolution of health in Europe. This project creates such a resource for basic health indicators readily obtainable from human skeletal remains.

In view of the extensive publications in physical anthropology and archaeology, it is fair to ask whether a large comparative study could be effective if undertaken from the published literature (including less accessible site reports) alone. We believe that it can be cost effective for one measure of health, average height. Accordingly we will collect these data, insofar as contextual information (such as the age of the site, and basic socioeconomic characteristics of the people who inhabited the site) is available from the source.

Average height, however, is primarily a childhood indicator of health that tells us little about the impact of environmental and socioeconomic changes on patterns of infectious disease, physical trauma or on degenerative processes such as dental decay and degenerative joint disease. To acquire this information, it necessary to return to the basic research materials, which are the skeletons themselves. There are three significant obstacles to using published sources for this purpose. First, our comprehensive review of the bioarchaeological and paleopathological literature shows that the entire body of publications is substantially incomplete with respect to basic health indicators. Many scholars are specialists who report in great detail on one or perhaps two aspects of health at a site, such as oral health or signs of disrupted tooth development, but without reference to other key health indicators such as stature, degenerative joint disease, or trauma. While something of interest has been assembled for many skeletal samples, collectively these publications are far from comprehensive in measuring the broad array of complementary health indicators available from skeletons.

Even if data collection were comprehensive for all attributes, idiosyncratic reporting standards would make any truly comparative study difficult or would greatly lessen its value. In the past few years, physical anthropologists have begun to devise comprehensive reporting standards for skeletal data (e.g., Buikstra and Ubelaker, 1994; Schultz, 1988). Such standards have not been widely employed until recently, and thus have not been incorporated into the vast majority of published reports. Instead, scholars have devised numerous distinctive ways to count or measure the number and severity of health indicators, such as the dental signs of disrupted development, and osseous lesions associated with specific nutritional deficiencies. This individuality adequately meets the goals of a research team preoccupied with the interpretation of a particular site or related group of sites, which has been the primary level of study among bioarchaeologists up to this time (e.g., various studies in Cohen and Armelagos, 1984; Larsen and Milner, 1994; Lynnerup, 1998; Storey, 1992; Arcini, 1999; Hemphill and Larsen, 1999; Grauer, 1995). We plan a much broader study, not just within sites but also across the countries and regions of Europe.

Finally, there is great value in obtaining the raw data on individuals as opposed to the aggregate statistics that are typically published in the literature. With individual data, researchers can precisely and consistently define age groups; study each component and the relationships among components of health, such as stature or dental decay; and investigate biological inequality within and across sites.

Large-scale comparative study of health using skeletal evidence has been undertaken by bioarchaeologists. In *Paleopathology at the Origins of Agriculture*, Mark Cohen and George Armelagos (1984) led the most ambitious early attempt. Contributors to this book assembled skeletal evidence of disease patterns that compared health in hunter-gatherer societies with that of settled agriculturalists. This transition has been long celebrated by social scientists as a major advance in civilization (Allport, 2000), but to the surprise of those outside physical anthropology, the book reported that health levels were lower under settled agriculture (for a review, see Larsen, 1995).

Critics of Cohen and Armelagos observed that the conclusions were dubious because contributors failed to use a standardized coding scheme for individual records. Most authors used a common set of variables, but specific measures were not reported using the same scales. Thus, precise comparative study was not possible using their approach.

Richard Steckel and Jerome Rose recently completed a large-scale, National Science Foundation supported, comparative study that resulted in *The Backbone of History: Health and Nutrition in the Western Hemisphere* (Cambridge University Press, forthcoming in early 2002). Participants in this project contributed data on 8 basic health or physical activity measures for 12,500 individuals who lived in the Western Hemisphere from roughly 4000 BC to the early twentieth century. All data were reported in the same format for a sample that included 10 percent European-Americans, 10 percent African-Americans and 80 percent Native Americans. The range of questions exceeds that in *Paleopathology at the Origins of Agriculture*, which focused mainly on health before and after the farming transition. The Western Hemisphere project considers issues over a broader time-span, including the dynamics of pre-Columbian health, the consequences of contact with Europeans, and the fates of Euro-Americans and African-Americans up to the early twentieth century. This work has been enthusiastically received at professional meetings as a powerful approach for addressing long-standing issues in the history of human health.

The present proposal represents a substantial geographic and chronological extension of the Western Hemisphere project. Aside from some modest additions (specific measurements important for estimating age and sex), the variables to be collected are identical (see below) and thus comparable. The Western Hemisphere initiative was therefore the first module of a much larger research agenda. The extension is important and valuable because the types of natural and socio-economic environments represented in the Western Hemisphere, and the documentary evidence of those environments are rather limited by global standards. Europe differed significantly from the Western Hemisphere with respect to factors that likely affected health, including plants and animals in use, the volume of trade, the timing and extent of urbanization, and the probable evolution of pathogens. The rest of the world differed importantly in the local environments created by exogenous forces such as climate, vegetation, and terrain, as well as internal forces such as political structure, conflict, and social organization. In addition, many sites in Europe are analytically more useful because a great deal is known about their environmental and historical contexts. In sum, the Western Hemisphere database is enormous by standards of work in the area, but is simply too small and lacks the diversity to address fundamental issues in changing health over 10 millennia in the world's many varied socioeconomic environments and ecosystems. Its comparative value, which is already considerable, will be greatly enhanced when combined with the data we propose to obtain from Europe.

C.II Skeletal Measures of Health

Human skeletal and dental tissues are highly sensitive to the environment. They provide a storehouse of information on health from conception through adulthood that can be combined with estimates of age and sex to provide detailed individual health histories, which can be merged to form a valuable picture of community health (Larsen, 1997). For this investigation, we will collect the following commonly accepted general health indicators for each skeleton:

• Adult height. Substantial evidence from the study of modern populations reveals that impoverished environments (i.e., poor diets, heavy disease loads, and hard work) suppresses growth in childhood and, if chronic and severe, substantially reduce final adult stature (Eveleth and Tanner, 1990). There is a large historical literature based on anthropometric records that explores the relationship between height and economic wellbeing (e.g., Komlos, 1989; Floud et al., 1990; Steckel and Floud, 1997; Steckel, 1995). We will greatly expand this research by using established procedures to estimate stature from long bone lengths (Sciulli et al., 1990; Krogman and Iscan, 1986).

• Enamel hypoplasias. Hypoplasias are lines or pits of enamel deficiency commonly found in the teeth (especially incisors and canines) of people whose childhood was biologically stressful. They are caused by disruption to the cells (ameloblasts) that form the enamel. The disruption is usually environmental, due to poor nutrition, infectious disease, or a combination thereof. Although nonspecific, hypoplasias have proven enormously informative about physiological stress in childhood in archaeological settings (Goodman and Rose, 1991; Hillson, 1996).

• Evidence of iron deficiency anemia. Iron is essential for many body functions, such as oxygen transport to the body's tissues. In circumstances where iron is deficient—owing to nutritional deprivation, low body weight, chronic diarrhea, parasite infection, and other factors—the body attempts to compensate by increasing red blood cell production (Walker, 1986). The skeletal manifestations of childhood anemia appear in those areas where red blood cell production occurs, such as in the flat bones of the cranium. The associated pathological conditions are sieve-like lesions called porotic hyperostosis and cribra orbitalia for the cranial vault and eye orbits, respectively (Stuart-Macadam, 1992). In infancy and childhood, iron deficiency anemia is associated with impaired growth and delays in behavioral and cognitive development (Lozoff et al., 1996; Walter et al., 1989; Ryan, 1997). In adulthood, the condition is associated with limited work capacity and physical activity (Scrimshaw, 1991). We are aware that not all examples of porotic hyperostosis and cribra orbitalia are indicators of anemia (Schultz, 1982, 1993).

• Trauma. Fractures, weapon wounds and other skeletal injuries provide a record of accidents or violence. Accidental injuries, such as ankle fractures, reflect difficulty of terrain and the hazards of specific occupations. Injuries caused by violence, such as weapon wounds or parry fractures of the forearm, provide a barometer of domestic strife, social unrest and warfare (various in Martin and Frayer, 1997; Walker, 1989).

• Infectious disease. Skeletal lesions of infectious origin, which commonly appear on the major long bones, have been documented worldwide. Most of these lesions are found as plaque-like deposits from periosteal inflammation, swollen shafts, and irregular elevations on bone surfaces (Ortner and Putschar, 1985). Most are nonspecific (the circumstances causing the infection cannot be determined) but they often originate with *Staphylococcus* or *Streptococcus* organisms. These lesions in archaeological skeletons have proven very informative about patterns and levels of community health (Larsen, 1997).

• Dental health. Dental health is an important indicator both of oral and of general health. The most accessible dental health indices in archaeological skeletons are carious lesions and antemortem tooth loss (Larsen, 1997; Ortner And Putschar, 1985). The former result from a disease process characterized by the focal demineralization of dental hard tissues by organic acids produced by bacterial fermentation of dietary carbohydrates, especially sugars. In the modern era, the introduction and general availability of refined sugar caused a huge increase in dental decay (e.g., Corbett and Moore, 1976). In the more distant past, the adoption of agriculture led to a general increase in tooth decay, especially from the introduction of maize (e.g., Larsen et al., 1991; and see Larsen, 1995). The agricultural shift and the later use of increasingly refined foods have resulted in an increase in periodontal disease, caries, tooth loss, and abscesses. The patterns of tooth decay and linkages with dietary and lifestyle changes have been studied in the Western Hemisphere but few have examined the timing and scope of regional differences in Europe, Asia, and Africa.

• Degenerative joint disease. Degenerative joint disease (DJD) is frequently observed in archaeological skeletal remains. The condition commonly results from mechanical wear and tear on the joints of the skeleton due to physical activity (Hough and Sokoloff, 1993). Generally speaking, populations engaged in physically demanding activities have more skeletal manifestations of the disease (especially buildup of bone along joint margins and deterioration of bone on articular joint surfaces) than populations that are relatively sedentary. Studies of DJD have been valuable in documenting levels and patterns of activity in past populations (Larsen, 1997).

• Robusticity. Skeletal robusticity refers to the general size and morphology of skeletal elements (Ruff, 2000). It is well known that bones are highly sensitive to mechanical stimuli, especially with regard to the ability of bones to adjust their size and shape in response to external forces. For example, foragers tend to be highly mobile, leading to elongated or oval femoral midsections, whereas farmers are more sedentary and have circular midsections (Ruff, 2000). These and other morphological differences reveal much about habitual patterns of physical activity and behavioral change over time (Ruff et al., 1993; Bridge, 1995; Larsen, 1997).

• Specific infections. Tuberculosis, leprosy, and treponamel infections are examples of diseases that often leave significant evidence on the skeleton. As these were major diseases in Europe over past millennia, we plan to record their presence or absence.

• Additional measures. As an aid to interpreting the above measures, we plan to collect a wide variety of skeletal indicators of health, based on the Buikstra and Ubelaker standards (1994) for about 5% of the total sample. This work will emphasize the use of newly developed histological and biochemical techniques. It is a worthwhile enterprise because of its potential to increase our understanding of the specific biological causes of pathological lesions in the skeletal collections we will examine.

C.III Age and Sex

Age and sex data provide essential context for analysis of health variations within and across populations. Physical anthropologists have developed accurate methods for estimating age-at-death and identifying sex from archaeological and other skeletons (White, 2000; Buikstra and Ubelaker, 1994). Age is determined for juveniles based upon the degree of development of teeth, long bones, and other skeletal elements. Adult age estimates are based upon morphology of the pubic symphysis and sacro-iliac joint, dental wear, and cranial suture closure.

Sex identification of juvenile skeletons is feasible under certain circumstances (Schutkowski, 1993), but the sexual distinctions become more pronounced during adolescence. Early in adulthood the female and the male pelves display distinctive morphological characteristics in size of the outlet and elongation of the pubic bone (Phenice, 1969; Buikstra and Ubelaker, 1994). Other distinctions appear in the skull, including greater robusticity among males compared to females.

C.IV Data Availability

In early June of this year, the PIs organized an NSF-sponsored workshop to inventory readily available skeletal collections and to discuss additional data sources (such as from climate history, archaeology, and historical documents), research methods and research themes for this project. The table below shows the inventory assembled from our European collaborators in physical anthropology, which include Pia Bennike, Laboratory of Biological Anthropology, Panum Institute, Copenhagen; Joël Blondiaux, Centre d'Etudes Paleopathologiques du Nord; Miguel C. Botella, Dept. Anthrop. Facultad de Medicina. Univ. Granada; Yuri K. Chistov, Physical Anthropology Department, Museum of Anthropology & Ethnography (Kunstkamera), St.-Petersburg; Alfredo Coppa, Department of Animal and Human Biology, Sec. of Anthropology, La Sapienza Univ. of Rome; Eugénia Cunha, Departamento de Antropologia, Universidade de Coimbra; Ebba During, Department of Archaeology, Stockholm University; Per Holck, Anatomical Institute, University of Oslo; Rimantas Jankauskas, Department of Anatomy, Histology and Anthropology, Vilnius Univ., Lithuania; Antonia Marcsik, Department of Anthropology, University of Szeged, Hungary; George Maat, Dept of Anatomy, Leiden; Anastasia Papathanasiou, Greek Ministry of Culture, Athens; Inna Potiekhina, Institute of Archaeology, National Academy of Sciences of Ukraine; Charlotte Roberts, Department of Archaeology, University of Durham; Michael Schultz, Zentrum Anatomie der University of Göttingen; Maria Teschler-Nicola, Dept. of Archaeology, Biology and Anthropology, Natural History Museum, Vienna. Among these collaborators, George Maat of the Netherlands will play a significant advisory role for the project in data collection and analysis, and Ebba During of Sweden will help the project coordinate financial payments in Europe through Stockholm University. We note that the inventory is incomplete, additional skeletons may be available to the project from other sources, and that permission or access issues remain for some collections.

Table 1: Distribution of skeletons by region and historical period

Historical Period	Scandin-avia	Western Europe	Southern Europe	Central Europe	Eastern Europe	Total	%
Post Medieval	1,476	7,829	360	0	4,729	14,394	10.9
Late Medieval	14,025	24,344	2,240	229	2,354	43,192	32.8
Early Medieval	4,201	20,174	1,740	2,623	9,330	38,068	28.9
Roman	0	8,657	2,125	591	1,399	12,772	9.7
Iron Age	12	514	5,111	500	2,462	8,599	6.5
Bronze Age	81	48	4,063	4,258	1,842	10,292	7.8
Neolithic	540	279	1,922	635	370	3,746	2.8
Mesolithic	90	0	121	0	288	499	0.4
Total	20,425	61,845	17,682	8,836	22,774	131,562	99.8
%	15.5	47.0	13.4	6.7	17.3	99.9	

The collections included in Table 1 are chronologically diverse and encompass a broad spectrum of ecological and socioeconomic conditions. While we have not yet gathered detailed information on all these collections, we can make some general statements. Although their numbers are relatively small in comparison to later periods, we include many of the key collections that document the transition from hunting and gathering to agriculture in Europe. The rise of cities and complex polities and the effects of European expansion, colonization, and industrialization are especially well documented with nearly 120,000 individuals available from sites used during the last two millennia. Materials from the medieval period onward are especially abundant, and when combined with the greater historical documentation of this era, these information sources give us our greatest potential for a refined analysis of the causes and consequences of health changes. The pattern of data availability will allow us to develop a stratified sampling strategy that maximizes our ability to determine the health consequences of a broad spectrum of ecological and socio-economic conditions in different regions of Europe.

A strategy for data collection is essential since we intend to process about somewhat less than one-third of the skeletons that are included in Table 1. In essence, we intend to pick first the "low-hanging fruit," defined by cost and by intrinsic interest of the collections. Cost considerations lead us to the museums with the largest skeletal collections, which are typically in metropolitan areas and where doctoral programs are already in place, insuring that graduate students will be available to assist with the project. We expect about 3/4 of the graduate students to be from Europe and the remainder from the United States. The American students will require support for travel and all students will need start-up expenses. Most of the data (in our estimate, about 85%) will be collected by graduate students, but we foresee the need to pay research assistants to collect data of considerable scientific value for the remaining 15% at locations where graduate students cannot be found to collect the data.

The environmental niche occupied by a group of people is a major determinant of intrinsic interest. A primary goal is to obtain adequate representation within all major categories, defined by natural environment (e.g., climate, vegetation, and terrain), time period, region, subsistence patterns, size and type of settlement, and economic, social and political structures. In addition, it will be analytically valuable to acquire more evidence for time periods on or near the cusps of major change, such as from foraging to farming, from dispersed settlements to urban areas, or immediately before, during, and after industrialization.

A third consideration is the quality of the collection in terms of state of preservation, completeness of skeletons, and related artifacts and historical sources that are available for study (to help determine status of individuals and socio-economic conditions in general). Size of the collection is also relevant. We would like at least 85 individuals at a site or related class of sites, to obtain some health information for both sexes and various age groups. About 50% of the 341 collections available for analysis meet this criterion. We also will use stratified sampling techniques to obtain data from large collections (more than 300 - 400 individuals).

Decisions on all these matters are judgment calls since we know of no formula that will establish, with the advantage of hindsight, an optimal sampling strategy. Yet we are acutely aware of budget concerns and will balance considerations of cost, interest, and quality of the collection. We are aware of trade-offs, and will expend, for example, more than average resources per observation in gathering data on a small collections from earlier groups whose characteristics are particularly interesting from an analytical perspective.

C.V Data Collection

Skeletal data. People familiar with the data collection plan for the Western Hemisphere project will know that costs were significantly reduced by using data previously collected by researchers. This procedure avoids the high cost of unpacking and repacking individual skeletons and the time required for data collection. This approach is feasible (we estimate) for 8,000 of the 40,000 skeletons from which we plan to collect data. For the remaining 32,000 observations we will have to measure directly from the skeletons.

It will be necessary to collect most of the raw data at the source in the museum repositories, which will occupy the first three years of the project. We envision the following sequence of steps: (1) design detailed coding procedures and a coding manual; (2) field test equipment and coding protocols; (3) collect the skeletal measures on individuals and obtain contextual information about sites from museums; (4) return the raw data to Ohio State University for cleaning, long-term storage, analysis, and distribution; (5) acquire additional environmental data, mainly from climate history; archaeological and historical sources and GIS about the habitat at each burial site; and (6) prepare and publish site reports that provide contextual information important for analysis of the data.

The coding manual will be an important training tool for those who collect the raw data or recode existing data sets and will also be essential for researchers who use the database. It will contain precise descriptions of each variable measured and will incorporate photographs that illustrate techniques and observational categories. The graduate students will be systematically trained in coding techniques, which will allow us both to estimate and minimize the magnitude of inter-observer error. The manual will be made available in notebook form, electronically on disks and via the Internet.

We will use advanced graduate students to field-test equipment and coding procedures. To simulate the actual research environment, groups of graduate students will be trained to collect and enter data on test collections. Where appropriate, they will enter data using electronic calipers connected to laptops, which will minimize data entry errors and expedite the collection process. We will develop software to detect observations outside plausible bounds. Observations on the same skeletons will be compared in studies of inter-observer error, and if found to be significant, the coding manual or collection techniques will be modified as necessary.

It will be the duty of the data coders to coordinate the gathering of readily available contextual information about each burial site. These include original excavation reports, field notes, conversations with those who conducted the excavations or who have worked at the sites, and actual visits to sites if nearby. In interpreting health, it will be important to know the settlement pattern, proximity to urban areas, likely rates of population growth, and probable diet of the population. Also relevant are available technology; economic, social, and political organization; the extent of trade; and archaeological contextual information.

Latitude and longitude will be reported for each site, to be used in linking the health data to environmental information available from GIS including terrain, elevation, weather patterns, vegetation, and proximity to water. Some variables such as vegetation and weather will require adjustments for historical changes, where feasible. Steckel and Walker (2000) have found the GIS information very useful in interpreting the variation in health patterns seen in the Western Hemisphere database.

In collaboration with archaeologists and museum researchers, the graduate students will summarize health and contextual information from each site in papers that will appear in *Global Bioarchaeology*, a journal that will be developed as part of the project. Immensely useful for understanding the causes and consequences of health patterns, these reports will also be accessible on the project's we page. The reports will also be organized in volumes with sections devoted to particular regions of Europe.

Through working on the project, the graduate students who gather the data and prepare the reports will acquire a repository of knowledge about the project and its database. This information will be of immense value for their own research and that of future researchers in ensuing decades. In addition, they will become collaborators with other researchers in interpreting the findings. In short, they will become part of the long-term human capital infrastructure created by the project.

Ecological or Environmental data. Three sources of information will provide the raw materials for our ecological and environmental database, which will be used to analyze health as assessed from skeletons. Over the past couple of decades, an enormous amount of information about climate history in Europe and elsewhere in the world has been gained from ice cores, tree rings, sedimentary deposits, and other sources (for a recent survey oriented toward historians, see Fagan, 2000). In an era when human adaptation to climate change was severely limited by technology and the extent of markets for food and other materials (which covers nearly all of the past 10 millennia), climate change could substantially impact human welfare. The human consequences of past climate change have been studied, but using gross measures such as the fall of civilizations (for the example of the Maya, see deMenocal, 2000).

This project brings a substantially more refined measure of adaptation, human health as measured by skeletal lesions, to the research table. Our advisors in collecting and interpreting climate data will be led by Lonnie Thompson of the Byrd Polar Research Center at Ohio State University. Also participating are Ellen Mosley-Thompson, Geography Department, Ohio State University; and Astrid E.J. Ogilvie, Institute of Artic and Alpine Research, University of Colorado. These advisors will participate and suggest other participants for a preconference and a main conference on climate data collection, analysis and interpretation.

Historical information or data important for providing a broad interpretative framework for change in the past (at least back to the time of the ancient Greeks in this project) come from numerous sources, including parish records, shipping records, wage rates, prices of various commodities, monastic records, censuses, harvest dates, wine yields, tax receipts, military records, royal archives, and so forth. There are already many descriptions and analyses of change in historical times from which the project can draw. But it will be necessary to collect some historical data for statistical analysis of the skeletal evidence. The PI (Richard Steckel) will coordinate this task, and will be assisted by the following people, who have agreed to advise or otherwise participate in the project: Joerg Baten, Economics Department, Tuebingen University, Germany; John Brooke, History Department, Ohio State University; Paul Evans, Economics Department, Ohio State University; Robert Fogel, Center for Population Economics, University of Chicago; Michael Haines, Economics Department, Colgate University; Barbara Hanawalt, History Department, Ohio State University; Peter Garnsey, History of Classical Antiquity, Jesus College, Cambridge University; Douglass North, Economics Department, Washington University; Geoffrey Parker, History Department, Ohio State University; Randy Roth, History Department, Ohio State University; Tony Wrigley, Cambridge University.

Archaeological artifacts and the context in which they were excavated are immensely valuable for interpreting the pre-historical past, but are also quite useful for understanding the historical past. The project will draw upon descriptions and analyses that have already been written, but like the case with historical documents, some data or information will have to be assembled for statistical analysis in this project. Advising us and suggesting participants for preconferences and conferences in these matters are: Brian Fagan, Anthropology Department, University of California, Santa Barbara; Henrik Jarl Hansen, Nationalmuseet, Denmark; and Luiz Oosterbeek, Instituto Politécnico de Tomar, Portugal, who will coordinate these activities.

C.VI Data Analysis

Health is a multifaceted concept that can be measured in numerous specific ways. Scholars generally agree on two key ingredients: length of life and health quality while living. The first is usually measured by life expectancy at birth (although other ages are also used, depending upon objectives). A variety of approaches have been taken to assess the latter, including illness rates for various diseases, days lost of school or work, and health interview surveys (for a discussion of data sources see Lansing, 1997).

In devising the health index used in the Western Hemisphere project, we adapted concepts called the quality of well-being scale and the health utility index (for a more detailed description of the index based on skeletal data see Steckel, Sciulli and Rose, forthcoming 2002). These measures score functional capacity at a particular age on a scale of 0 to 1 and incorporate tradeoffs between length of life and the health quality of life (Kaplan and Bush, 1982; Torrance and Feeney, 1989). The idea was to roughly approximate such a measure using information available from skeletons. Quality was measured by the prevalence and severity of skeletal pathologies within 7 basic health indicators: stature, dental health, linear enamel hypoplasias, porotoic hyperostosis, trauma, skeletal infections, and degenerative joint disease. Age-specific scores (ranging from 0, the highest degree of pathology, to 100 denoting the absence of pathology) of these attributes were then weighted equally to calculate an overall index. Individuals with low scores led lives of greater pain and with more limitations on capacity for work and enjoyment of life. We intend to use this index for assessing health across sites in the present project.

This health index is obviously limited in focusing on chronic conditions measurable on skeletons. But acute infectious diseases that leave no traces on the skeleton usually pass quickly, having little impact on average quality measured over the typical length of life. One may debate whether the attributes should be weighted equally, but without additional research on the functional implications of the scores, it is difficult to justify an alternative weighting system. As implemented for the Western Hemisphere project, the health index revealed important, plausible variations in health across environments and over time. For example, confirming earlier expectations based on various reports in Cohen and Armelagos's *Paleopathology at the Origins Of Agriculture*, the health index was generally higher (representing better health) for foragers than for farmers. In any event, researchers who may disagree with the concept of the index or with its specific implementation are free to analyze, in any way they wish, the basic data we will collect. Relevant to this point, the bulk of the budget for this project is devoted to data collection as opposed to analysis and interpretation.

We will estimate the average length of life from the distribution of the ages at death at various sites. As Robert McCaa (forthcoming 2002) and Sheila Johansson and Douglas Owsley (forthcoming 2002) report in their essays for *The Backbone of History*, paleodemographers making estimates of life expectancy have often assumed that a population was stationary or had an unchanging age composition. This assumption may hold approximately for large regions, but it is suspect or requires justification at the local (site) level. They note the sensitivity of the age distribution of deaths to the birth rate, and they also show the value of information on the birth rate (or the population growth rate) in reducing the standard errors of estimated life expectancies. Hence, we will collect contextual information that will shed light on likely population growth rates, which will improve the precision of life expectancy estimates. It is unlikely that substantial precision will be attainable, but based on our experience with the Western Hemisphere database, grouping estimates of life expectancy within categories as narrow as 6 to 7 years would be plausible for many sites. Information of this sort is quite useful and worth incorporating into the ranking and investigation of health by sites.

Analysis of the data will proceed in two directions: exploratory data analysis and hypothesis testing. The first is necessary and valuable because little large-scale comparative work has been done. Of course, we will have results and hypotheses formulated from the Western Hemisphere project and from other published literature, but the data we will collect are unique with respect to their sample size and diversity. The field of comparative study on this scale is simply not sufficiently well established to provide a deep well of plausible generalizations or hypotheses upon which we can draw. Indeed, one of the major goals of this project is to create a large database that is important for defining such a field. Therefore, we will engage in patient sifting of the evidence, guided by other empirical results and findings from modern or historical studies of health, for which there is abundant information.

We will test hypotheses concerning the determinants of health, often using regression analysis, but other key statistical analyses will be performed where appropriate. Typically, the health index or one of its components (or the average of groups thereof, such as childhood health indicators) would be the dependent variable. But where appropriate, we will also use direct measurements, such as femur lengths, that are recorded in the database. The explanatory variables will be suggested by the hypotheses under investigation, and they are straightforward in the case of ecological variables often studied by physical anthropologists, such as climate, vegetation, topography, settlement size, and subsistence patterns. Technology in use as well as measures of political, economic, and social organization are also independent variables that flow from modern medical-anthropological research on the determinants of health.

We recognize that the documentation and interpretation of health levels, using archaeological human remains, are not always straightforward. That is, temporal changes in the frequency of lesions associated with infection or growth disruption are not always a reliable indicator of change in community health, broadly defined. While our analysis will adjust for the age distribution of deaths by converting the prevalence of lesions to age-specific rates, we will also be alert for the possibility that sudden declines in health (as measured by life expectancy) might not register on bones simply because the observable lesions often take time to accumulate. It is important that we look at multiple indicators of health, and that we examine carefully other lines of evidence that inform the understanding of health in a particular setting, such as subsistence and settlement, environmental context, cultural context, and population structure (Walker, 1996). We will look for consistency of patterns and specific exceptions to these patterns that may represent what has been become known as the "osteological paradox" (Wood et al., 1992).

C.VII Analytical Projects and Publications

A long list of valuable research projects can and will be undertaken with the data we will collect. Our current priorities are outlined below, but we want to emphasize our flexibility and willingness to listen to advice. During the first three years, the PIs will attend numerous conferences, not only to promote the project and advertise the new database, but also to interact with a wide range of social and medical scientists and to seek input and suggestions for the research agenda. Our plans for conferences leading to books will unfold beginning in the third year (the last year of data collection) by assembling lists of researchers who would like to participate. At pre-conferences beginning late in the third year, preliminary results will be presented and discussed in shaping a precise list of papers to be given and discussed at a subsequent conference. Following this, the papers will be revised and submitted for publication as a conference volume. This formula has worked well in other projects organized by Richard Steckel and co-investigators, including *Health and Welfare during Industrialization* and *The Backbone of History*. Eventually, with funds sought through other proposals, the PIs and co-author(s) will prepare one or more synthetic books that will distill results from all conference volumes for a general audience.

The first project will focus on health, climate and habitat. The effects of the physical environment in which people lived should be measured and understood before attempting to study the relationship of health to social, economic and political processes. Of course, in doing this it will be necessary to control for factors known to influence health such as diet, settlement size, and the extent of interaction with the outside world. To this end, we anticipate a sequence of papers that investigates health of different groups, such as hunter-gathers or settled agriculturalists, in various physical environments defined by climate, topography, elevation, vegetation, and proximity to water. This project is given priority because of great policy interest in climate change and human adaptation and because it is important to understand the consequences of ecological variables before proceeding to socioeconomic analysis.

The shift from hunting and gathering to farming is the most important human transition of the past 10 millennia. All other developments leading to the creation of modern societies have flowed from this fundamental change in the way people acquire and distribute food. It is therefore important to understand when and why it occurred and to measure its effects on health. Three distinct hypotheses, each with somewhat different implications for health, will be investigated (Smith, 1995; various in Price and Gebauer, 1995). Some have suggested the transition was a second-best alternative, in other words the deterioration of opportunities for foraging, perhaps from over-use of the environment, drove hunter-gatherers into agriculture. If correct, one would expect to find a decline in health before the transition occurred and that the most marginal foraging areas were first in making the switch. Alternatively, leaders may have convinced (or coerced) members of hunter-gatherer bands into settled agriculture as a way to redistribute power and resources that benefited the leaders. Under this scenario, biological inequality and related objects of status would have increased after the transition. Finally, many or most members of the hunter-gatherer bands may have sought the change if they thought that the workload was lighter. If correct, measures of physical exertion, such as degenerative joint disease and skeletal morphology, would have changed after the shift in lifeway. Although only about 5% of the skeletons available for study span the Mesolithic-Neolithic transition (Table 1), the absolute number is adequate for analysis, and in any event, additional skeletons may be available.

The social and economic causes and consequences of long-term changes in health will be next on the research agenda. The causes include the significant socio-economic changes made by humans over the past several millennia, such as urbanization; European expansion and colonization; industrialization; and major new technologies for food production, transportation or warfare. This project will anchor its comparative study in the last 3,000 years and especially the past millennium, a period for which considerable contextual information is available from historical and archaeological sources. The this juxtaposition of historical and skeletal data will make it possible for us to develop a new, more reliable, perspective on the socioeconomic history of Europe in which skeletal data are used as an independent check against interpretations based literary sources and historical records.

Using health as a central measure of human welfare, in collaboration with Paul Evans of the Economics Department at Ohio State University, we will be able to shed new light on the longstanding debates over the prime movers of very long-term processes of economic growth. According to Maddison (1995, pp. 19, 20), world per capita output has increased sevenfold since 1820, and Western Europe and its offshoots have experienced even more growth. Although the world essentially experienced no substantial and long-lived (over at least one century) in real per capita income prior to the nineteenth century, considerable growth in population and technological progress did take place (Kremer, 1993; Mokyr, 1990). One might explain the pre-nineteenth century growth experience using Malthus (1798), according to whom advances in technology induced population growth by increasing living standards. In the growth experience of the past two centuries, technological progress has won the race against diminishing returns, and consequently the early postwar growth literature essentially replaced diminishing returns with constant returns (Solow, 1956; Swan, 1956, Cass, 1965; Koopmans, 1965).

Following the important contributions of Romer (1986) and Lucas (1988), a growing literature has sought to model technological progress as arising from endogenous choices of profit-maximizing innovators (see for example, Aghion and Howitt, 1998; Grossman and Helpman, 1991). The endogeneity of technological progress opens up an additional channel by which long-run diminishing returns to labor can be eliminated. At least three papers have attempted to reconcile Malthus with modern formulations of the sources of economic growth based on constant returns. Hansen and Prescott (1998) posit two technologies for producing output in which the constant-returns technology progressively supplants the diminishing returns technology. Galor and Weil (2000) conclude that there was a very long-lived growth path in which per capita consumption was constant, population grew slowly, and technology improved slowly. Eventually, the long-run features of technology kicked in, a demographic transition occurred, and a new growth path was approached. Jones (2001) uses a model of fertility choice to argue that a strong positive relationship between income and fertility existed at low incomes but a negative relationship existed at moderate to high incomes. Jones combines these preferences with a technology that exhibits decreasing short-run returns to labor and weakly increasing long-run returns. Ultimately, the level of per capita income is determined by the condition that the induced level of fertility must just suffice for zero population growth.

Using the data collected in this project, we will be able to test these hypotheses, insofar as skeletal health is an adequate proxy for human welfare. According to the Hansen/Prescott and Galor/Weil models, per capita consumption should have been essentially constant before the era of modern growth, but the Jones model allows for periods during which human welfare improved measurably because of bursts in innovative activity or unusually favorable institutional changes. Jones' model can therefore be regarded as proposing the alternative hypothesis to the null hypothesis proposed by the Hansen/Prescott and Galor/Weil models.

The final analytical goal of this project will be to examine long-term trends in the quality of life for women and for children, which have been little studied, even for the recent historical period. Up to 30 years ago, the neglect might be explained by scholarly emphasis on understanding the actions of important leaders and decision makers, who were overwhelmingly adult men. But more recent efforts make clear both the importance and practical difficulty of documenting the lives of these historically under-represented "forgotten ancestors." Women and children left few tracks in that part of the historical record created by writing contracts, owning land, engaging in remunerative work, or holding office. Research by economic historians has brought to light the great value of average stature in understanding important aspects of the quality of health for women and children (Steckel, 1998), and this project extends that work by collecting and analyzing skeletal indicators of health for 40,000 individuals. The data are reasonably abundant, allowing us to make the most comprehensive investigation to date of the health of these neglected groups and to study the conditions under which their health improved or declined relative to that of men or adults over the millennia.

The budget for this project anticipates four conferences, but depending upon advice of scholars, one of those described above could be displaced by others on our immediate priority list. Eventually, we anticipate that a series of additional projects will be undertaken by us, by our collaborators, or by others. These additional projects will involve considerable collaboration with experts in the relevant fields. We anticipate the following subject areas: (1) Trauma and violence. Skeletons reveal fractures, weapon wounds, and signs of abuse. We can study the conditions under which they were frequent or infrequent; (2) Biological inequality. Various techniques of measuring inequality of wealth or income can be adapted to measuring biological inequality, a topic of growing interest to scholars; (3) Aging and health. The quality of life for the aging population has long been on the research agendas of social scientists, and we will have ample data to investigate their health relative to that of younger individuals; (4) Health in the rise and fall of civilizations. Historians have long considered the evolution of major civilizations as possible guides to our own future, and we will have considerable evidence to add to this research agenda; (5) Geographic patterns of health. Work in this area will extend from the first conference on health and habitat, summarizing all findings for groups studied; (6) Degenerative joint disease. We expect medical scientists will be quite interested in origins and evolution of this modern health problem; (7) Population genetics and DNA analysis. Our database will be a valuable resource for researchers interested in extraction and analysis of global migration patterns; and (8) Genetic co-evolution of humans and pathogens. DNA from pathogens is preserved in ancient human remains and promises to provide important information on the evolution of diseases that have had profound influences on the recent history of our species, such as tuberculosis and the plague.

In addition to the initial broad projects outlined above, the data collected will be useful for numerous subsequent research projects. We plan to foster graduate student research on more focused topics, such as refining GIS studies of the ecology of specific diseases; apparent or actual osteological paradoxes; various studies of the environmental causes and socioeconomic effects of each of the basic health indicators; health and long-term economic growth; microclimates and health; and skeletal adaptations to activity levels under various socio-economic regimes. Additional research opportunities also exist to use the database in ways that complement studies in archaeology, history, economics, sociology, demography and other social sciences.

Near the end of the project, we will schedule a conference inviting 10 Ph.D. students and their major advisors. These conferences will be devoted to the discussion of the data and its uses in dissertations. At professional meetings, through professional journals and via the project's web site, we will advertise this program and solicit proposals. The program will endeavor to attract women and minority doctoral candidates. The conferences will explain precisely the data collected, the methods used in collecting the evidence, the selection of skeletal samples, and the meaning of ecological variables. We will promote a seminar-like atmosphere that will facilitate the free exchange of ideas and that will sharpen the focus of dissertation research. If the program is as successful as expected, we will apply later for grants to extend this activity.

C.VIII Data Distribution

After the first book from the project is published, we will distribute three types of information: site reports, a package of environmental variables about the sites, and the raw data collected from individuals who were buried at the sites. The reports will follow a standard format beginning with the exact location (latitude and longitude) and relevant maps. Following a brief summary description of health, the report will discuss physical aspects of the site such as terrain, vegetation, elevation, climate, and proximity to water. These site reports will also contain what is readily known about social, economic, and political activities as well as discussions of technologies in use, settlement size, proximity to urban areas, the importance of trade, and subsistence patterns. These reports of about 4-5 pages each will be made available in the project's journal, *Global Bioarchaeology*, which will be available on the project's web site. Information useful for analysis of health, including GIS data, will be distilled into an environmental database that will be packaged with the skeletal data.

The raw data will comprise a large file—about 40,000 observations on the 8 basic indicators of health or activity patterns, several measurements important for determining age and sex, plus a large ecological and environmental database depicting conditions at the sites where people lived. With present technology, the database can be distributed via the Internet, and we will also sell CDs of these data at cost at various professional meetings. Because we have observed misinterpretations of data collected by someone else, we will strongly urge users of the data we collect to consult relevant participants in the project for advice in data analysis or interpretation. Thus, participants in the project will serve as repositories of knowledge and advice about the database.

Personnel at the Center for Human Resource Research will be readily available to advise us in the cleaning, compilation, storage, and distribution of data. Housed at Ohio State University since the late 1960s, this group manages several very large longitudinal databases of individual and household records of economic and social activity known as the National Longitudinal Survey (NLS). We will also benefit from a working relationship with the Center for Spatially Integrated Social Science (CSISS) and other research groups at the University of California at Santa Barbara.

C.IX Project Administration

The project will be coordinated, and research will go forward with the assistance of a project administrator who will coordinate staff, manage budgets, communicate with researchers in the field, and help plan meetings and conferences. This person will also be the managing editor and copy editor of the journal *Global Bioarchaeology*. As needed, expertise will be hired to develop and maintain the project's web page, develop software to extract GIS data useful for analyzing health, conduct statistical analysis, programming, and preparation of maps.

Periodically the PIs will prepare newsletters for communication with the interested public. Distributed and archived on the project's web site, the newsletters will discuss goals of the project, progress in data collection, and preliminary results. These publications will also advertise conferences, answer questions, and submit queries.

Among the principal investigators, Richard Steckel will have overall responsibility for management of the project, a role he played in the Western Hemisphere endeavor (Steckel and Rose, forthcoming 2002). Paul Sciulli will have primary responsibility for cleaning, storage, and distribution of the data, a job he performed on the Western Hemisphere project. With their extensive global connections, Clark Larsen and Phillip Walker are well suited to coordinate contacts and relationships with museums, and they will also play a vital role in the analysis and interpretation of the data.

While on sabbatical during the first year of the project (2002-2003), Steckel will oversee data collection activities in Europe. Larsen and Walker will travel to Europe and elsewhere as needed. Walker will also coordinate the collection of GIS data, a task made easier by his proximity and working relationships with geographers at Santa Barbara, who are strong in this area. A division of labor based on interest and expertise will be developed for the additional tasks that remain.

We recognize that the administrative requirements of the project are formidable. Coordination of a trans-Atlantic effort in data collection, analysis and distribution will require a well-trained project administrator and PIs who are readily available to absorb information and make wise decisions. All the PIs are senior researchers who have considerable experience as administrators, and all were associated with a smaller version of the current project (devoted to the Western Hemisphere) as organizers or participants. Steckel is a leading authority on the use and analysis of large public databases and has extensive experience in coordination of large research projects involving multiple collaborators. Larsen and Walker have directed large-scale bioarchaeological research programs involving extensive research collaboration for more than two decades in various places in the world, mostly supported by the National Science Foundation. Sciulli was responsible for compiling, cleaning, and managing the database for the Western Hemisphere project. We note, too, the extraordinary growth in communications capability that has occurred in recent years, especially with the rise of the Internet. Indeed, we doubt that the project would have been feasible (i.e., close to cost effective) even a decade ago. But the opportunity now exists to use the new technology in extending our research horizons.

At the end of the grant period, the PIs will seek funding to maintain the database on a long-term basis. Future researchers are likely to expand the number of skeletal observations as new material becomes available through excavation or access to museum collections. In addition, some work will be required to update the environmental data file as additional information becomes available from archaeological and GIS sources. In addition to the project's web site, we will store various updates of the data at other accessible locations such as ICPSR.

C.X Legacy

The global health history project offers a new and exciting way of collecting and analyzing large data sets in anthropology and using them for research in the social and medical sciences to build an understanding of the history of human health. Six key benefits will emerge from this infrastructure project:

- A large, publicly-accessible database of 8 general health indicators and related textual description for the skeletons of approximately 40,000 men, women and children who lived throughout Europe over the past 10 millennia. At the end of the project, we will create a permanent administrative structure that will continually update the database;
- A companion database of ecological, economic and social variables describing the environments of the roughly 500 sites where these individuals lived, which provides information important for analyzing and interpreting health;
- A database of basic health indicators that can be linked to additional data collected by future researchers;
- Four conferences and associated conference volumes addressing central questions in the history of health, including health, habitat and environmental change; health and the transition to farming; the social and economic causes and consequences of long-term changes in health; and the health of women and children. The infrastructure we create will make many additional large-scale projects possible;
- Dissertations of at least 10 Ph.D. students, guided in part by the PIs in using the data for their research, with efforts to fund more if this endeavor is successful;
- A substantial heritage of human capital, which will lay the foundation for a new approach to studying health, in the form of training for physical anthropologists in broader questions and methods of the social sciences; education of many social and medical scientists in methods of physical anthropology and the uses of skeletal data; and ties among an international network of scholars committed to studying the global evolution of health.

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