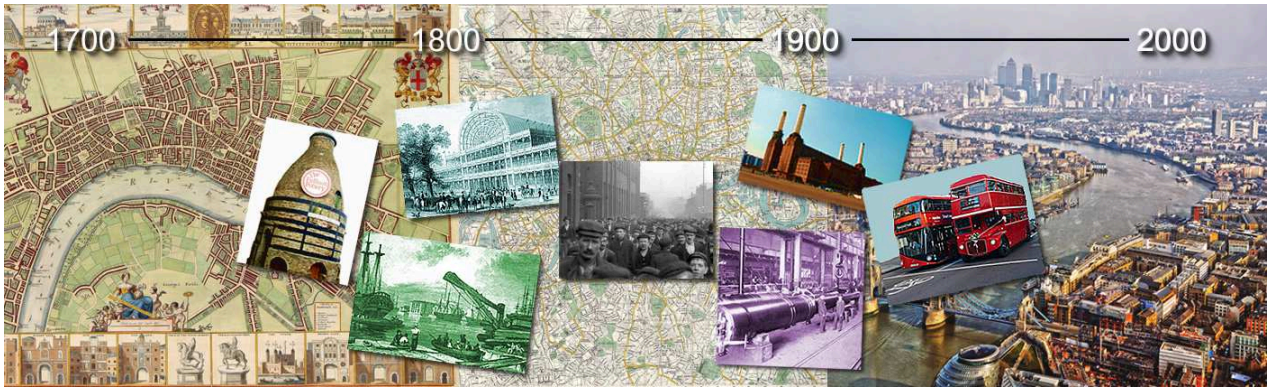
CoLAT

The City of London Archaeological Trust



The Impact of Industrialisation on London Health

A three-year research project by the Centre for Human Bioarchaeology at the Museum of London, beginning April 2015.

Funded through a generous bequest to the city of London Archaeological Trust (CoLAT) by the late Rosemary Green, a new research project based upon the analysis of the archaeological human skeletal remains of 2,500 individuals hopes to uncover new clues about how the nature of disease affecting the UK's population has changed over the past millennium. Modern health trends have seen a shift towards increasing life expectancy but also what are often thought of as 'man-made' conditions such as obesity and cancer. Given our technologically driven lifestyles today, far removed from the more physically active, organic existence of the majority of our forebears, there are questions about the origins of these diseases and how they relate to the modern environment. Are these diseases genuinely recent or is it that they couldn't be identified before? To what extent is our modern, artificial environment responsible for the diseases that we experience today? How has the industrialisation of modern society impacted on our health?

These are some of the questions that this new research project aims to address by analysing diseases affecting the human skeleton, focussing on the impact of the industrialisation process on London populations. **Jelena Bekvalac** and her research team **Gaynor Western and Mark Farmer**, based at the **Centre for Human Bioarchaeology at the Museum of London**, will use the latest clinical techniques to quantify the presence of a number of selected skeletal conditions and to assess their change over time. The research aims to examine the influence of the Industrial

Revolution, a pivotal catalyst in the formation of our modern environment, on the changing nature of disease from the medieval and post-medieval periods through to the present day. The project offers an exciting opportunity to digitise some of London's most important skeletal collections while simultaneously producing a stimulating and up-to-date medical narrative about the health of Londoners over time, highlighting the relevance of archaeological assemblages, in particular those of the historic periods, to the modern day agenda of health and the environment. By engaging **digital radiography, CT scanning and 3D modelling**, the project will culminate in the creation of an extensive new digital resource that can be explored interactively online to examine the effects of the Industrial Revolution on the skeletal remains of Londoners in comparison to assemblages from across the country.

Initial applications of digital radiography at the Centre for Human Bioarchaeology have already provided valuable insights into critical factors of some newly prevalent diseases. For example, **Hyperostosis Frontalis Interna**, or HFI, is a condition regarded as being more prevalent in modern populations due to the effects of industrialisation (Figure 1). Associated with the menopause, obesity and diabetes as part of Morgagni-Stewart-Morel syndrome, it is occurring in record numbers of female patients today but the exact cause is still unknown. Increased exposure to oestrogen over a lifetime has been identified as a potential key factor of the condition in females and this could be related to longer life span as well as other factors such as reduced family size leading to fewer offspring. Contrary to some current medical hypotheses, our new data so far suggests that while increased lifespan is a critical factor, the number of offspring does not appear to influence the occurrence of this condition. Building upon these initial investigations, this research project will look at the factors contributing to health today by analysing a much larger sample of skeletal remains and taking a broader, interdisciplinary approach. The new funding provided by CoLAT will allow us for the first time to integrate the latest research from the field of medicine, the medical humanities and archaeology to explore the influence of industrialisation on health up to the present day.

The Industrial Revolution is one of the most important eras in history to influence human development since the discovery of fire, the cultivation of crops and the domestication of animals. In London, it created substantial economic opportunities, exploiting the benefits mechanised production offered to exponentially increase manufacturing and trade. London became the largest manufacturing town in Europe. Steam and coal replaced wood burning and were harnessed to fuel new machinery developed to replace manual labour and hand production. Metallurgy, chemical, glass and textile manufacture were all modernized on an industrial scale. Life-enhancing technologies were also developed that irreversibly altered how we communicated and interacted. For example, unparalleled engineering feats led to new and more efficient transport infrastructure. The canal network, docks, improved roads and later the railway network were introduced to transport raw materials, goods and people more quickly across the country. London was also a prominent place for medical study. Medicine quickly became a scientific endeavour and understandings of disease, its transmission and curative treatments were rapidly expanding.

However, the darker side of the revolution was the creation of a human work-force

organised on an unprecedented scale as an extension to the swathes of volatile and dangerous equipment. In the mid nineteenth century, one third of London's inhabitants were involved in manufacture. Many of the new technological developments were highly dangerous and exposed workers and the environment to toxic chemicals. London's population had grown from 870,000 in 1801 to over three million by 1871. An endless sea of chimneys from factories and new houses belched out tonnes of carbon pollution and other noxious fumes. Green areas around the city were now being swallowed up by an expansion of vast areas of slum dwellings without sanitation. Manufacturing innovation abounded but the new wealth brought extreme social divisions, with high levels of poverty, overcrowding and pollution. According to Chadwick's survey of 1842, life expectancy for labourers and servants in London was just 22 years compared to an average of 45 years for the gentry and professional classes. Record numbers of people were now living in squalor and working in hazardous environments. Life for these people was dominated by poor nutrition, infectious and occupational diseases that were often fatal. Contagious diseases such as tuberculosis, measles, and scarlet fever were commonplace in these damp and cramped conditions, while cholera epidemics and typhoid, caused by the consumption of polluted water, were rife.

Outside of London, the period saw extensive changes to agriculture, with advanced machinery replacing manual labour in the fields. New adaptive strategies were taken to increase the crop yields, including an intensification of land use. Additionally, new crops such as sugar and even fresh foods like meat were increasingly imported into the country from abroad via refrigerator ships as international contact expanded. Shipping of food stuffs across the country also became cheaper and more efficient as a result of the newly constructed canals and improved roads. These significant advances in agricultural and food technologies led to an economic crisis in the countryside and many workers were forced to migrate and seek employment in the new urban industries. Having endured waves of out-migration, disease and famines, some rural settlements went into decline and were abandoned. In those small towns and villages that did thrive, however, inhabitants often enjoyed a greater life expectancy of around 41 years, similar to that of the gentry in the City, due to the cleaner, safer surroundings and better diet.

Social reforms were introduced throughout the latter half of the 19th and early part of the 20th century as a response to these catastrophic outcomes of industrialisation in the urban centres. In tandem with significant medical advances, this fundamentally revolutionised health and the environment as we experience it today. Legislation improved housing, public sanitation, working conditions and provided free health care to all by the creation of the NHS. We now live longer and are able to prevent or treat infectious diseases that were fatal only a few decades ago. According to the Office for National Statistics, life expectancy in the UK today is 81.5 years and has increased at a faster pace in London compared to other regions. However, as a result a major contributing factor towards many diseases we see today is age. Age-related conditions are now on the rise as we are now an aging population. The Economic Policy Committee of the European Union predicts an increase in our old age population to 52% by 2030. Other diseases becoming more common, like type 2 diabetes, are related to obesity, resulting from a more sedentary lifestyle and a higher consumption of sugary foods, saturated and trans fatty acids. Of course,

industrialisation continues to thrive and of great concern today are pollutants, such as the Persistent Organic Pollutants (POPs) that are most often generated through industrial and chemical processes. These man-made organic compounds are resistant to environmental degradation and can accumulate in people's bodies through dietary and air intake, potentially posing a significant risk to human health and the environment. The effects of such environmental pollutants and the mechanisms of many modern diseases are still unknown: the most tangible evidence we have for the long-term consequences of the industrialisation process upon our environment, health and well-being is written in our bones.

Archaeological skeletal assemblages hold the key to understanding our health in the past yet their potential to unlock the shifts in health that we see materialising in modern populations has been somewhat limited to date. The relatively recent recognition of the importance of studying skeletal assemblages from the post-medieval period has now culminated in the development of a substantial archive of these remains in London, held by the Centre for Human Bioarchaeology. These collections can help us to understand much more clearly the underlying changes in our environment that are influencing our health for better or worse. Although documentary evidence exists for the period, causes of death and diagnoses of illness are often lost in archaic medical terms, and were ascribed upon the basis of empirical experience rather than scientific knowledge. The skeletal remains, however, which are contemporary with the Industrial period, form a unique source of tangible evidence for disease in the past that can be objectively assessed according to modern, clinical criteria. These collections also often consist of individuals whose biographical details are known (i.e. age, sex, family history etc), giving us vital information that we can use to investigate key factors contributing to diseases.

However, not all skeletal diseases can be detected by the naked eye and we need to use modern imaging techniques to fully investigate pathology in these skeletons. **Direct Digital Radiography** (DDR) allows visualisation of the internal structure of the bone to detect the earlier stages of diseases or diseases that do not affect the external surface of the bone (Figure 2). A light weight and easily deployable unit uses a unique high sensitivity portable flat panel detector A digital conversion process converts the raw image to digital form to produce a high-resolution, high-contrast greyscale image in less than 0.03 of a second. Advanced image processing software allows 'on the fly' interpretation and evaluation, meaning that a large number of images can be taken and analysed rapidly, which is ideal for population based studies. **Computerised Tomography** (CT) is generally hospital based and will be undertaken at Moorfields Eye Hospital for this project. It can be used for early stage pathological diagnosis as well as clarification of lesions detected by DDR that are non-diagnostic. CT is a lengthier, more involved method of bone analysis since it scans the bones in slices and produces an image of each slice. However, it reveals greater detail than DDR. CT images can also be reconstructed to allow 3D volume rendering and can produce 'cut away views' of parts of skeletal elements that otherwise are obscured from view (Figure 3). By applying the same imaging techniques and recording methodologies used in hospitals today to the archaeological skeletons, we will be able to reconstruct a complete timeline of disease prevalence from the medieval period right up to the present day.

Using this digital technology, we will examine the skeletal remains of over 1000 adult men and women from Industrial period London in addition to a further 500 individuals who lived in the medieval city. The analysis will identify cases of key diseases including **Hyperostosis Frontalis Interna** (HFI), **osteoporosis, joint disease, trauma, neoplastic disease and Diffuse Idiopathic Skeletal Hyperostosis** (DISH) (Figures 4 and 5). Each one of these conditions is frequently cited as being more prevalent in clinical populations as a result of our modern lifestyles or is associated with an enriched lifestyle. This will give us a large new source of reliable, objectively observed information about the health of Londoners in the past. Our findings will allow us to compare the numbers of cases of each condition to those in modern day populations. We can then ascertain whether these conditions really are a modern phenomenon or whether cases from the past have gone undetected from a lack of our ability to detect them without the use of modern imaging techniques.

The London post-medieval population will consist of individuals of all social status and, since many of these remains are of identified individuals, we will be able to use existing historic documentary evidence such as baptism and burial records to establish family history and to independently verify sex and age at death. We can, therefore, look at factors such as age, sex, family size and status to investigate how the process of industrialisation affected different individuals from different areas of the city (Figure 6). To extend this line of enquiry further, we will also be looking at groups of people living outside of London at the time, as the majority of the English population did and still do. The process of industrialisation throughout the country was not uniform and comparing the London data to that from non-metropolitan settlements will best capture the affect of living within the highly urbanised environment of the City. In order to achieve this, the remains of 500 post-medieval individuals in addition to 500 medieval individuals from small towns and cathedral cities will be examined to identify cases of the diseases described above. Archaeological and historical evidence for the nature of the physical surroundings for each site will also be gathered to place the skeletal data into its appropriate environmental context.

An overview of the major findings will be published as a synthetic volume, complemented by more detailed forthcoming journal publications. The project will contribute to research programmes for a variety of communities, from local archaeological groups to international scientific organisations. Importantly, the digital radiographs, **CT scans and 3D models will provide a vital new resource of 2D and 3D images** of the diseases under study, providing a large collection of additional archive material for future teaching, learning and exhibitions. The immediate accessibility of such an archive via online or in-house digital sources will allow anyone interested in exploring the themes of the project to engage interactively with the new data. The new information will also be integrated within the series of popular public outreach and education programmes held by the Centre of Human Bioarchaeology at the Museum of London, who can be contacted for more details of forthcoming events. Some illustrations showing aspects of the research follow below.

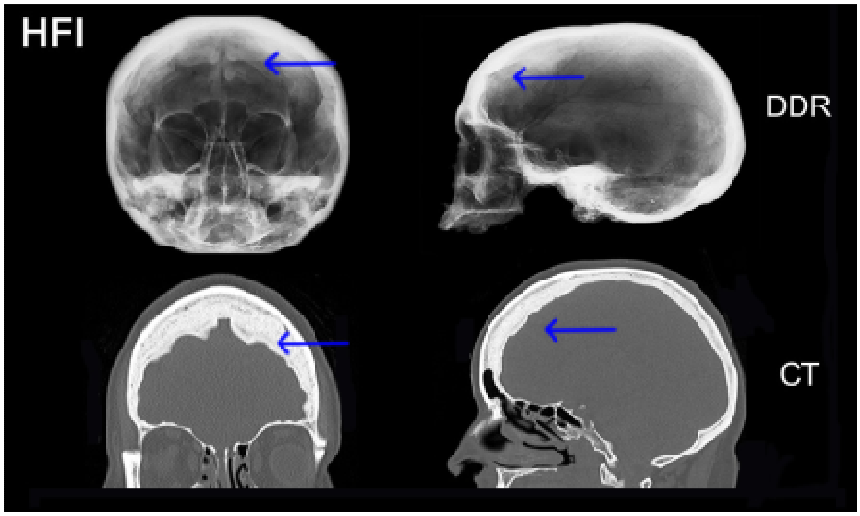


Figure 1: Composite digital images of crania with arrows indicating areas of pathological change associated with Hyperostosis Frontalis Interna (HFI). Initial research identified a link to older age in females but no link to the number of their offspring.

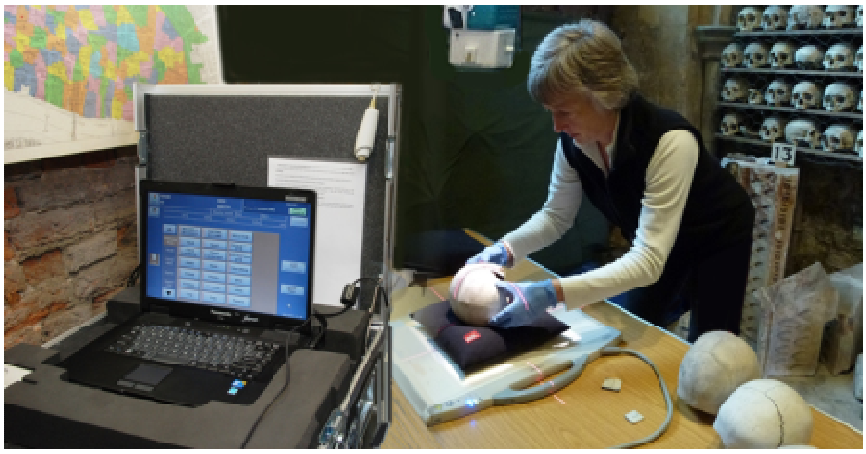


Figure 2: Portable Direct Digital Radiography (DDR) equipment. The portability enables easy and fast set up with instant access to radiographic images on screen and an ability to see any pathological changes occurring inside the bones. (Hythe Crypt, Reveal Imaging).

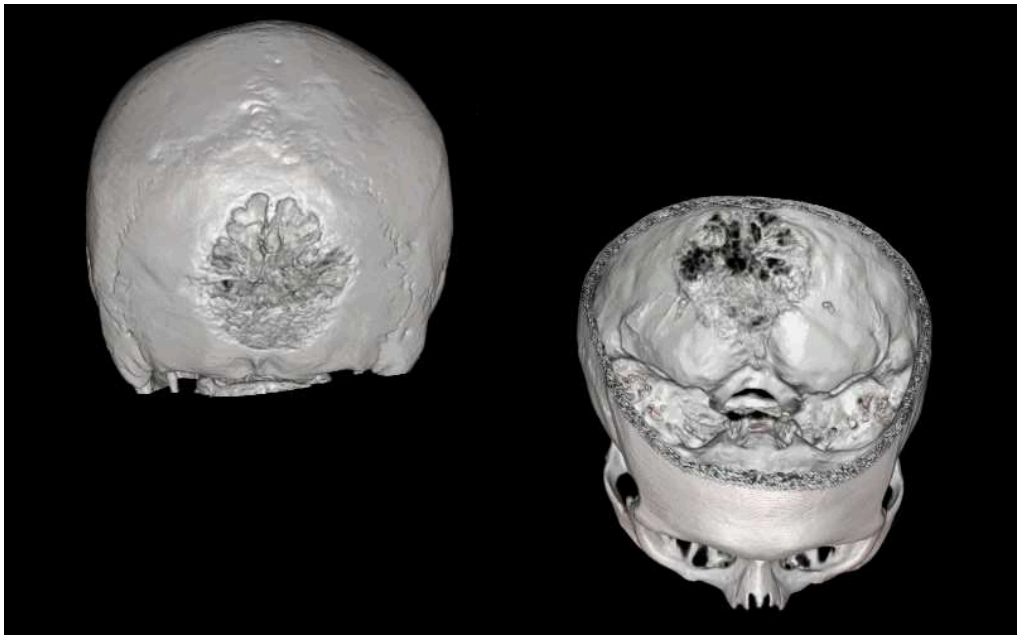


Figure 3: CT scan of a neoplastic lesion, with external (left) and ‘cut-away’ view (right).

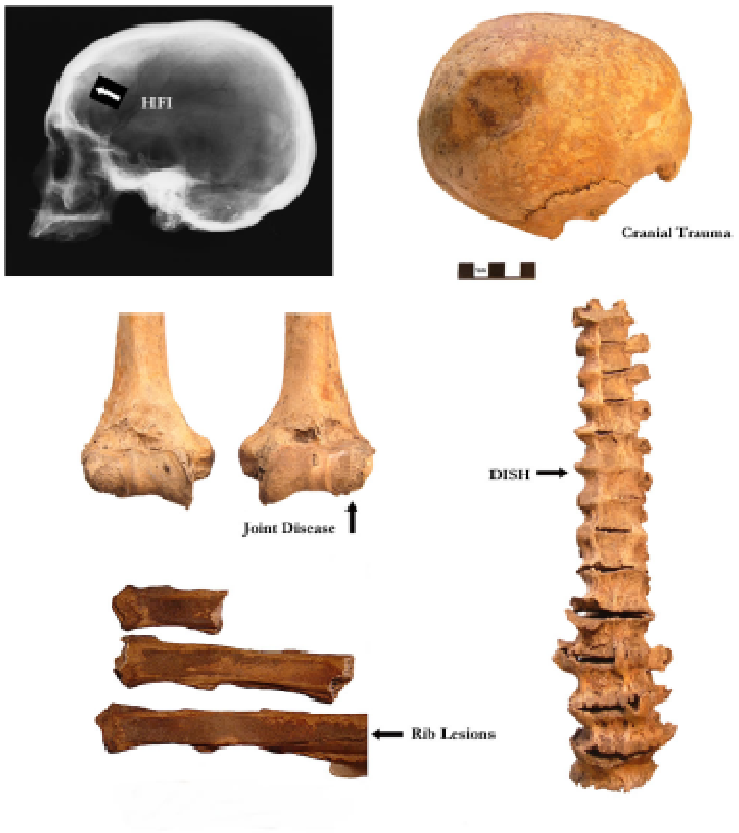


Figure 4: Examples of the types of pathologies selected for the research project to help ascertain if the prevalence of these diseases can be linked to industrial and modern lifestyles

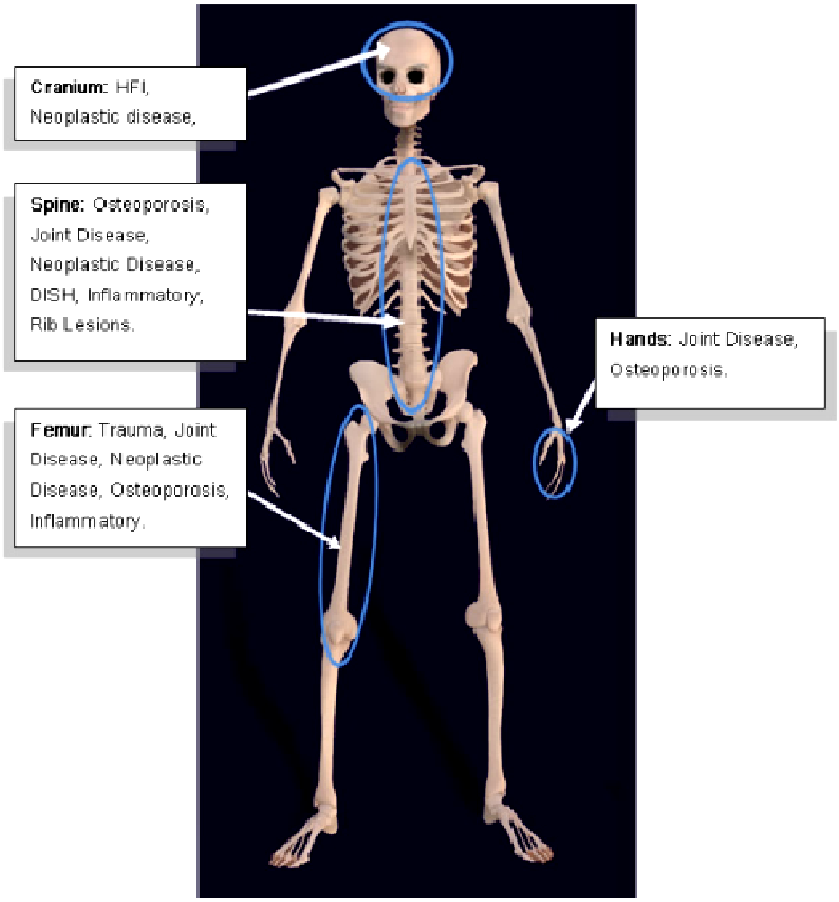


Figure 5: 3D model skeleton illustrating the anatomical areas and the selected diseases targeted

For more information, contact: Jelena Bekvalac, jbekvalac@museumoflondon.org.uk.

For the work of the City of London Archaeological Trust (CoLAT), contact the Secretary, John Schofield, john@jschd.demon.co.uk.