A Decade of Advances in the Paleopathology of the Ancient Egyptians

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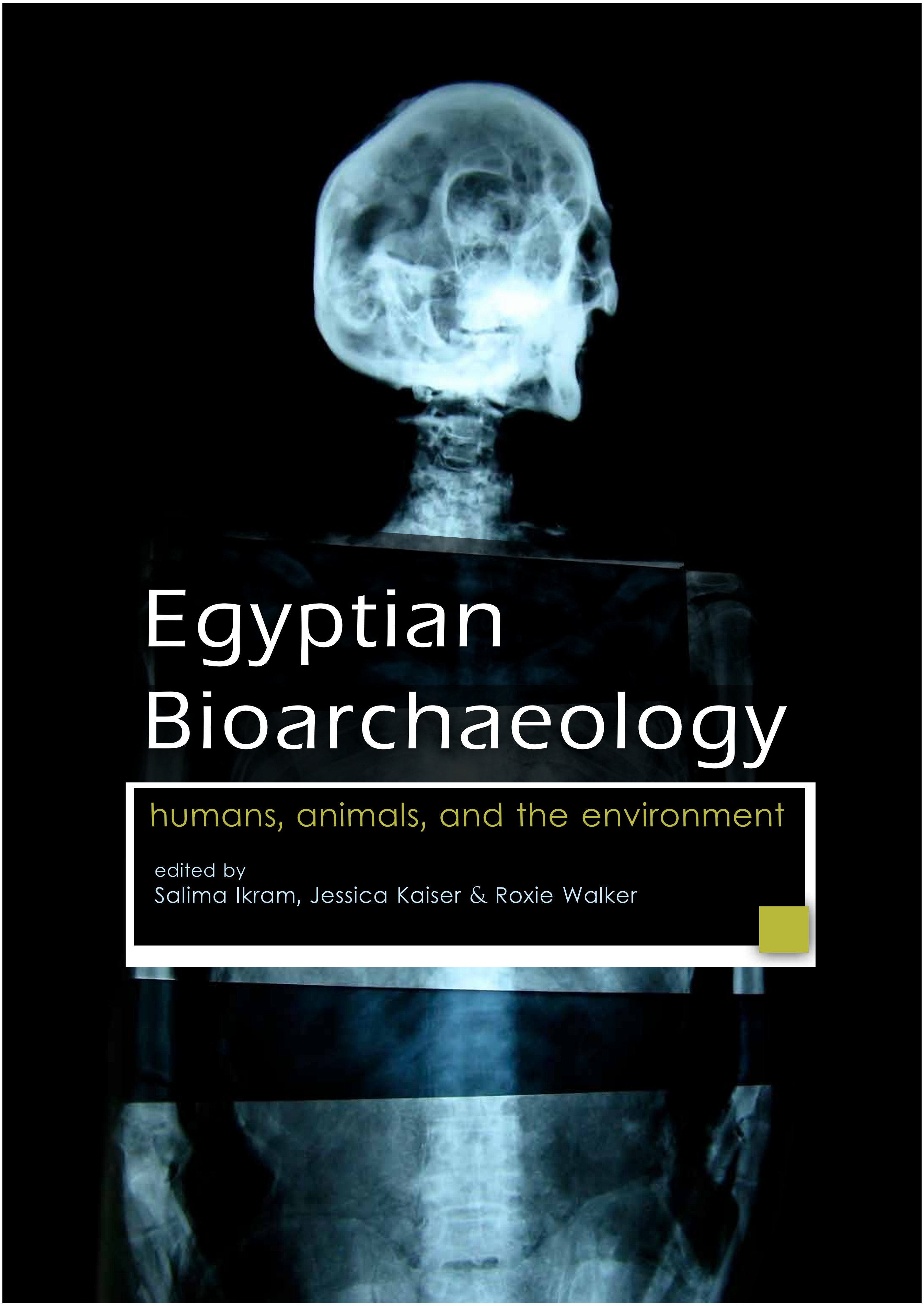

Egyptian Bioarchaeology

humans, animals, and the environment

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Our understanding of disease in ancient Egypt has changed substantially within the last decade or so. This has been made possible by dramatic advances in medical engineering and biomedical techniques, particularly the growing sophistication of computed tomography (CT) and the ability to recover DNA from ancient bacteria and viruses. This paper will present the latest discoveries about tuberculosis, cancer and heart disease in ancient Egypt, three diseases about which our evidence and understanding have changed the most.

The study of ancient human remains has always gone hand-in-hand with the technology used for study of living patients. When X-rays were discovered in 1895, the technique was tried out in Frankfort on the mummy of an ancient Egyptian child just four months later (Adams and Alsop 2008: 21). By the 1970's computed tomography (CT) had been developed, and CT was first successfully used on a mummy in Toronto in 1976 (David 2008: 42). Now CT-scans are standard in any mummy study.

DNA was first recovered from an ancient Egyptian mummy in 1985 (Pääbo 1985), and with the development of polymerase chain reaction, informative sequences of DNA can be specifically targeted. Although the amount of ancient DNA that can be recovered is limited, it is now recovered from bacteria and viruses, and this is changing our understanding of ancient disease. Specifically, our understanding of tuberculosis in ancient times has changed remarkably since the late 1990's due to work with ancient DNA. Not only has *Mycobacterium tuberculosis* DNA been recognized in ancient Egyptian human remains, but also particular strains of *Mycobacterium* have been distinguished (Zink *et al.* 2002: 142-144; 2003b).

Bones are mainly what have been studied for evidence of past disease, and for *Mycobacterium tuberculosis* that means identifying bone lesions, particularly in the thoracic and lumbar vertebrae, although these bone changes can also be caused by other pathological conditions (Brown and Brown 2011: 851-853). But, in their most destructive form, these lesions cause vertebral collapse and fusion, producing the curved spine often called "Pott's disease", named after Sir Percival Pott, a London surgeon who first described it in 1779. In 1909, Derry (1909: 31-32) published the first description of Pott's disease in ancient Egyptian and Nubian remains.

The physical evidence used for a tuberculosis (TB) diagnosis did not change until 1979, when Zimmerman published microscopic confirmation of pulmonary TB. He was able to identify TB bacteria in the vertebrae and red blood cells in the trachea and lungs from a hemorrhage, he assumed was the cause of death, in a post New Kingdom mummy of a child from Thebes (Zimmerman 1979: 606-607). The next development came in 1997 when Nerlich and Zink announced the retrieval of a DNA sequence from the lung tissue of a New Kingdom Egyptian mummy, a 35-year old man from the West Bank of Thebes that showed

> *"homology to the DNA of* M. tuberculosis*"* (Nerlich *et.al.* 1997: 1404).

This molecular evidence backed up a macroscopic examination, showing evidence of pulmonary tuberculosis (Nerlich *et al.* 1997).

In 1998, a team, working with Crubézy at Adaima in Upper Egypt, was able to retrieve a DNA fragment from bone samples from a Predynastic Period child with Pott's disease that was:

> *"sequenced and is consistent with an original* Mycobacterium *sequence"* (Crubézy *et al.* 1998: 941).

Subsequent work suggested that this DNA was an ancestral form of *Mycobacterium tuberculosis* that existed when urban life emerged in Egypt beginning around 3400 BC (Crubézy *et al.* 2006). The skeleton of another young child with multiple bone tuberculosis from the same cemetery was published in 2011, providing a similar picture of a period where tuberculosis must have been endemic (Dabernet and Crubézy 2011).

Zink and Nerlich and their team continued to extract DNA from bone and tissue samples from three groups: Early Dynastic Period burials at Abydos, Theban burials dating to the Middle Kingdom to Second Intermediate Period, and Theban burials of New Kingdom to Late Period date. A total of 83 samples were taken. Out of these, 18 of them tested positive for *Mycobacterium tuberculosis* complex DNA. Of these, six came from individuals with macroscopic evidence of "tuberculous spondylitis" (Pott's disease), five from individuals with "non-specific pathological alterations" (lesions that could be from TB or something else), and seven from individuals with "normally appearing vertebral bones"(no osteologic sign of TB) (Zink *et al.* 2001; Zink *et al.* 2003a: 242-244). They concluded that for about 2500 years the frequency of tubercular disease in ancient Egypt remained the same, roughly about 25% (Zink *et al.* 2003a: 248). Two years later the team had analyzed a total of one hundred and sixty bone and tissue samples, and thirty-eight of the samples, coming from all three different time periods,

> *"tested positive for the presence of mycobacterial DNA"* (Zink *et al.* 2005: 85).

These samples were

> *"further characterized by spoligotyping"* (Zink *et al.* 2003b: 365).

The Early Dynastic material produced evidence for an ancestral strain of *Mycobacterium tuberculosis*, while the Middle Kingdom samples were characterized by *Mycobacterium africanum* strains. The samples from the New Kingdom to the Late Period revealed

> *"a modern strain of* M. tuberculosis*"* (Zink *et al.* 2007: 388).

No evidence for the strain of *Mycobacterium bovis* was found in any of these samples. It has always been thought that *M. bovis* was ancestral to M. tuberculosis, and that the disease passed to humans at the time they domesticated cattle in Egypt, approximately 4500-5000 BC (Roberts and Manchester 2005: 184). It has now been shown by a 2007 publication of Iron Age skeletal material from southern Siberia, that the earliest evidence of *M. bovis* DNA in human remains dates from the late 1st c. BC to early 1st c. AD, suggesting a somewhat late and Eastern origin for this strain of tuberculosis (Taylor *et al*. 2007).

Nerlich and Lösch (2009) reviewed these findings, and discussed the possible interaction of climate and pathogen in the evolution of a "modern" strain of *M. tuberculosis*. The question of climate change at the end of the Old Kingdom is an on-going one, and the latest core sample from the Nile Delta, published in July 2012, gives further evidence of a drought with "a sustained effect" in the Nile Valley 4,200 years ago, perhaps providing the environmental pressure necessary for such a change (Bernhardt *et al.* 2012: 617).

One last development in the search to identify ancient tuberculosis is the technique that can detect mycolic acids in the *Mycobacterium tuberculosis* cell wall. Mycolic acid can be extracted, and examined by high performance liquid chromatography, to identify what type of cell it came from (Gernaey *et al.* 2001). This technique was used in the recent re-examination of the Granville mummy, a Late Period older female named Irtyersenu from Thebes. This mummy had been first autopsied by Granville in 1825 who declared that ovarian cancer was the cause of her death (Granville 1825: 298 and pl. 22, 1). A new study in 1994 concluded that her tumour was a benign cystadenoma (Spigelman and Bentley 1997: 107; Sandison and Tapp 1998: 51). Histological study of the mummy found evidence of a pulmonary exudate, so samples from her lungs, gall bladder and membranous tissues were tested for *Mycobacterium tuberculosis* DNA, and samples from her femurs and lung were tested for mycolic acids of *Mycobacterium tuberculosis*. All DNA and mycolic acid samples were positive, and it appears that an active tuberculosis infection was the cause of Irtyersenu's death (Donoghue *et al.* 2010)

The question of whether or not cancer is an "old disease" has been brought up again in recent studies discussing the evidence for cancer from ancient Egypt (David and Zimmerman 2010). CT-scans of a Ptolemaic Period male mummy 50-60 years old showed bone lesions in his pelvic bones and vertebrae, characteristic of metastatic prostate cancer. This is the first time that prostate cancer has been found in an ancient Egyptian mummy, and the authors suggested that the cause of death was

> *"osteoblastic metastatic disease"* (Prates *et al.* 2011: 101).

Most scholars have considered cancer in ancient Egypt to be rare, or "meager". But in a study of 280 Late Period individuals, Strouhal and Vyhnánek (1981: 184) found four examples of metastatic carcinoma, which they stated is "not negligible". Zink and others found four cases in 325 adult individuals dating New Kingdom to Late Period, which they said, "provides clear evidence that malignant tumors were not a rare event" (Zink *et al.* 1999). In a later, related article they stated that the rate of tumor frequencies from ancient Egypt was found to be comparable with that found in bones from a southern German ossuary dating AD 1400-1880, as well as with the frequency expected when compared to an early 20th c. AD English control population (Nerlich *et al.* 2006).

Evidence for heart disease in ancient Egypt is also being reevaluated. Artery calcifications in the mummy of an elderly female had been first recognized in 1852 (David 2010: 107). Later in 1909, sections of the aorta of King Merneptah were taken, and its plaque formations discussed in the Royal Society of Medicine (Shattuck 1909). So, the existence of the disease was known. The latest and largest CT study of ancient Egyptian mummies, called the Horus Study, identified atherosclerosis and heart disease as a significant problem among the upper class of ancient Egypt, particularly the priestly families. So far they have published the results for 52 mummies, 45 in the Egyptian Museum, Cairo and seven from two museums in the US, ranging in date from the early New Kingdom to Roman times (Allam *et al.* 2009; 2010; 2011). Of these mummies, 44 had "identifiable cardiovascular structures", and 20 of these, or 45%, had "definite or probable atherosclerosis". Calcifications were found in the arteries of the pelvis and legs, as well as the aortic and carotid arteries. These 20 mummies had an average age of 45 years, and were fairly evenly divided by sex: 55% male, and 45% female.

Not only does atherosclerosis seem to be related to age, therefore, but also diet. These people scanned were elite, so they could afford to be mummified, and in life they had daily access to "luxury" food such as beef, which was offered in temple rituals, and then reverted to the priests for food (David 2010: 111-114). A high beef diet has been clearly shown by the food refuse outside the priestly quarters of the mortuary temple of Senusret III at South Abydos, where beef bones made up roughly 95% (Rossel 2004). The refuse is described as

> *"an immense pile made from the leftovers of choice cuts of juvenile cattle"* (Rossel 2006: 43).

The latest conclusion of the Horus study, after doing CT-scans of mummies from ancient Peru, ancient Puebloans of southwest America, as well as the Unangan of the Aleutian Islands, is that atherosclerosis was

> *"common in four preindustrial populations",*

and therefore may be

> *"an inherent component of human ageing", rather than a disease of modern life* (Thompson, et al. 2013: 11).

This conclusion has also come from much older evidence than that in Egypt. Ötzi the Iceman, was found in the Italian Alps in 1991, and dates back to around 3300 BC, or contemporary with the Egyptian late predynastic. His DNA showed that he had a predisposition to cardiovascular disease, and CT-scans showed he had atherosclerosis (Murphy *et al.* 2003: 627)

A follow up to the Horus Study discussed the cardiovascular disease of Lady Rai, who was CT-scanned as part of the Horus study, and that of modern women in Egypt (Abdelfattah *et al.* 2012). Lady Rai was a royal nursemaid in the very beginning of the 18th Dynasty, and may have taken care of the future King Amenhotep I. She died between the ages of 40-50. Her coronary arteries could not be clearly seen, but she had an area of calcification in the posterior wall of her heart that might have been from a prior heart attack, and calcifications could be clearly seem in her thoracic aorta. In terms of modern Egyptian women, the article concluded on the basis of patients presenting to Cairo University Hospital, that they are suffering from

> *"an epidemic of atherosclerotic cardiovascular disease"* (Abdelfattah *et al.* 2012: 1),

and although women present with heart disease at an older age than men, they are more likely to be obese and diabetic. Not only does heart disease seem to be a part of the human condition, but also, it should not be considered a health problem that mainly affects males.