

New directions in the archaeology of medicine: deep-time approaches to human-animal-environmental care

Naomi Sykes and Julia Shaw

TOWARDS AN INTEGRATED ARCHAEOLOGY OF MEDICINE AND HEALTHCARE

The maintenance of human health and the mechanisms by which this is achieved – through medicine, medical intervention and care-giving – are fundamentals of human societies. However, within archaeological discourse, investigations of medicine and care have tended to examine the obvious and explicit manifestations of medical treatment as discrete practices that take place within specific settings, rather than broader indicators of medical worldviews and health beliefs. In terms of human remains analysis, discussions have generally focused on the identification and diagnosis of palaeopathologies (e.g. Roberts and Manchester 2007; Grauer 2012) or unusual examples of surgical intervention (Mogle and Zias 1995; Bernardini et al. 2012; Becker 2014). Material studies have centred on medical implements (Baker 2004; Jackson 1997) with less attention given to investigating the less tangible pharmacopoeia.

Matczak and Wojciech (this volume) provide an excellent summary of the development, approaches and key sources concerning ‘medical archaeology’. As is made clear, the research area is advancing fast with a large number of high-quality publications being produced in recent years, including the British Archaeological Reports (BAR) Studies in Early Medicine Series that followed from a number of workshops and conferences from the late 1990s. In 2013 Baker published her important *Archaeology of Medicine in the Greco-Roman World*, and 2017 saw the publication of ground-breaking volumes on archaeological approaches to care (Powell et al. 2017; Tilley and Schrenk 2017). Nevertheless, the research area is still nascent, especially when compared with the intersecting discourse brought together within the Medical Humanities, including the History of Medicine and Medical Anthropology. Both of these fields are large, well-defined and well-funded, with their own research degrees and academic journals (notably *Journal of Medical Humanities*, *Medical History*, *Medical Anthropology*, *Journal of the History of Medicine and Allied Sciences*). This volume sets out to make the case that there is potential for archaeology to develop its own subfield along similar lines, as our discipline has the ability to improve diachronic understanding of medicine and healthcare and to contribute to a range of

emergent fields such as community and public health (Deprez and Thomas 2016), environmental and planetary health (Watts et al. 2017; Whitmee et al. 2015), genetic and epigenetic medicine (Parry and Dupré 2010), microbiome studies (Adler et al. 2013; Warinner et al. 2014; Hendy et al. 2018; Schnorr et al. 2016), and historical disability studies (Linker 2013).

In order to achieve a viable new subfield, there is a need for archaeologists to forge better links between the biomedical sciences and medical humanities. The latter, in particular, would help archaeology to move beyond a presentist and Eurocentric understanding of 'medicine' as a set of discrete drug-based 'treatments' in the modern clinical sense. This bias has coloured archaeological understandings of ancient medicine and healthcare, with interpretations tending to be both reductive and out of step with the rich evidence from the medical humanities. The history and anthropology of medicine have demonstrated repeatedly that in many societies – past and present – medicine, care-giving, and knowledge of human anatomy, are multifaceted and widespread. Concepts of medicine and care weave through all aspects of daily life (including choices regarding everyday diet, clothing or personal adornments) and are often linked directly with religio-ritual frameworks, notions of religiously ordained duty or status (for example, caste in India), and are entwined with culturally specific attitudes towards food, body and constitution (Shaw 2016a).

These studies also highlight the shortcomings of adopting anthropocentric approaches to medicine and healthcare since, in many cultures, humans and non-humans are perceived as indivisible (e.g. Shaw 2016a, Sykes 2014). The privileging of humans as the focus for research has not only erased non-hominids from archaeologies of medicine and care (although see Thomas 2017 for a rare summary of archaeological approaches to animal care), it has also seen little attention given to other human species. Spikins et al. (this volume) review the evidence for Neanderthal healthcare, drawing on a bioarchaeology of care approach and relating healthcare to other realms of Neanderthal social life and death. The authors argue that Neanderthal medical treatment and healthcare were part of a social context of strong pro-social bonds, little different from healthcare seen in later contexts. In so doing they highlight that the traditional reluctance to accept a situation of active care for Neanderthal injuries is part of an outdated trope that emphasises differences between Neanderthals and modern humans.

MEDICINE AS WORLDVIEW

As Spikins (this volume) stresses, systems of healthcare (to which might be added health beliefs, symptoms and notions of pain) cannot be understood outside of their social and

cultural context. Our position here is that the definition of medicine and healthcare should encompass cultural worldviews, including aspects of religio-ritual thought and practice, and related ontological frameworks. For example, Currie et al. (this volume) argue that mistrust between modern biomedical or pharmaceutical-led medicine, and Complementary and Alternative Medicine (CAM) is connected to the former's dislocation from religious-ritual practices, which in many parts of the world are central to medical practice and health beliefs. Currie et al.'s exploration of Andean health beliefs and related medico-ritual practices, for instance, shows them to be deeply entwined with traditional ontologies and shamanistic cosmologies. Viewing medical practice and healthcare as worldview mirrors similar revisions in scholarly understandings of religion, no longer viewed as a set of discrete theologies and rituals, but rather as a set of worldviews and ontologies (Shaw 2013b). In keeping with this broader religion-medicine analogy, Currie et al examine ways in which Andean populations pick and mix from Andean and western medicine for different medical complaints, as does Rice (this volume) for Peru. Similarly, within 'religion-as-technique' (Shaw 2013a) or 'medical' models of religious change in anthropology (Peel 1968; Goody 1975), 'converts' to evangelical religions such as Christianity or Islam may continue to worship indigenous gods for specific aims, drawing on the analogy that the acceptance of allopathic medicine for a cough does not preclude the continued use of traditional medicines for other ailments.

A scholarly understanding of pre-modern medical worldviews needs to be situated within an overview of the history of European medicine. Prior to the Enlightenment of the 18th century, ideologies followed the Humoral medical model, whereby the workings of the human body were seen to mirror their immediate physical and elemental environment (e.g. see Horden and Hsu 2013; Scully 1995; Arikha 2007; Sykes 2014; Jones et al. 2016). According to the Humoral perspective within early European medicine, the four elements- air, earth, fire and water- and all physical matter, were a mixture of four opposing qualities: heat, cold, dryness and wetness. Together these elements and qualities were perceived to shape an individual's 'temperament', with four main constitutions - sanguine, choleric, melancholic, phlegmatic – as conceived in Galenic medicine. The maintenance of an individual's humoral balance was considered vital, with any deviation having the potential to cause serious damage to health. Maintaining such a balance was complicated by the fact that an individual's humoral make-up was not fixed but changed and varied according to personal character, sex, season and life stage (starting moist and becoming progressively dry with age). Furthermore, health and wellbeing could be influenced by the temperament of the foods/drinks humans consumed, the environment/climate in which they lived or the company in which they mixed. This was because temperaments could also be transferred through all the senses - sight, sound, touch and smell - as well as through consumption. As such, maintaining good health was a highly individual matter, perhaps the earliest form of personalised medicine, as attested through the creation,

translation and exchange of medical texts throughout the ancient world (Afif et al. 2018; Burkert 1995; Pormann and Selove 2017; Unschuld 2010).

Given the prevalence of Humoral-oriented models of medicine in many historical contexts, the near total absence of any discussion of elemental and humoral theories in current archaeological dialogue is astonishing (Jones et al. 2016) and it is refreshing to see several of the papers in this volume redressing this situation. For instance, Baker (this volume) discusses how Greco-Roman concepts of humors and elements saw regional body types and constitutions directly impacted by the local environment, but also how individual susceptibility to health, wellbeing and illness were closely bound up with Roman notions of good versus bad air. Baker approaches this interesting material largely through the prism of sensory perception and the aesthetic experiential dimension of 'natural' spaces, with both the visual and aural dimensions, as well as pleasant smells, contributing to wellbeing.

Whilst the Humoral understanding of the physical world is particular to the history of European medicine, parallels can be drawn with non-European medical epistemologies that exhibit similar underlying structures and principles to the present day (see for instance Anderson 1987; Ahmad and Qadeer 1998; Foster 1994; Horden and Hsu 2013; Messer 1987; and other papers in the *Social science & medicine* 25(4) special issue *Hot–cold food and medical theories. Cross-cultural perspectives*). Such perspectives are well represented in this volume. For example, both Rice and Currie et al highlight the resemblance of Andean herbal-based medicine to humoral medicine, whereby Andeans' bodies are conceived as mirrors of their environment so that the balance and health of both are believed to be intertwined and mutually dependent (Bastien 1981, 1985; Mendoza 2003).

There are also interesting parallels between European humoral medicine and Indian ontologies such as the Sāṃkhyan concept of *Puruṣa/Prakṛti*, whereby *Puruṣa* refers to the universal or individual soul and 'knower' of *Prakṛti*, insentient or 'productive' matter, that comprises *kṣetra*, as both 'field' and 'body' (Malinar 2014, 38, 2016). Here the 'field' acts as a metaphor for the human body (with veins and arteries called by same terms as used for canals, pipes, waterworks in irrigated rice) and the planting, cultivation and harvest of acts (*karma*) (Malinar 2016). Such blurring of human:non-human boundaries offers scope for tackling human:nature inequities which, as discussed within bioethics discourse (e.g. Büchler 2012), stem directly from Eurocentric frameworks of embodiment and associated legal jurisdiction that prioritize the human body above non-human entities (Shaw 2016a-b). A similar level of non-dualism is also central to Indian medico-ecological frameworks in which healthy soils and healthy bodies are seen as analogous. For example, the classical Ayurvedic medical texts suggest that some pre-industrial categories of 'pure' or sacred places, land and water overlapped closely with medico-

ecological categories, with certain places believed to impart healthy (or harmful) 'imprints' on the human body by virtue of their geological or botanical profile or anthropogenic alteration (Zimmermann 1980, 2004). The link between climate, environment, illness and healing is further highlighted, with humid, 'swampy' environments being associated with phlegm-related problems, remedied by meats and honey from 'dry lands' whose 'harsh and light qualities compensate for the excesses of the climate' (Zimmermann 1980, 105).

Archaeological enquiries of medicine and materia medica can benefit from such approaches that acknowledge the multi-sensory variables (including taste, touch, sight, sound and smell), in addition to foods, physical objects (for example, amulets) and materials, air-borne pollutants, and environments, which can shape human health and wellbeing.

IDENTIFYING MATERIA MEDICA AND MEDICAL PRACTICE IN THE ARCHAEOLOGICAL RECORD

The World Health Organization (WHO, 1993) estimates that about 80 per cent of the world's population – six billion people – rely primarily on traditional animal and plant-based medicines, a point supported also by a range of anthropological studies (e.g. Alves and Rosa, eds. 2014; Costa-Neto 2005; Insoll 2011; Lev 2003; Morris 1998). This widespread use of traditional medicines today may be contrasted with their apparent lack of visibility in the archaeological record. A major contention of this volume is that the archaeological identification of traditional medicines is hampered by post-Enlightenment preconceptions about what medicine actually is (i.e. a set of discrete drug-based treatments) and how it should be practiced (i.e. as a 'science' set apart from religio-ritual sphere). As discussed by Currie et al, and Rice (this volume) by excluding this religio-ritual sphere, a significant dimension of medical practice is erased from the field of enquiry, with traditional medicine rendered invisible because it is not considered to be legitimate medicine in the first place.

The oft-discussed unilinear evolution from humoral-based 'folk' medicine, to the 'rational science' of organ and germ-based models of the human body and disease, went hand in hand with longer standing polarisations between professional, usually state-sanctioned, physician-based medical practice and the traditional knowledge of the apothecary / herbalist (Elmer 2004). Just as European colonial administrators dismissed traditional medical systems as ineffective at best, and primitive and dangerous at worst (Currie et al., Rice, Reifschneider, this volume), a similarly polarised set up today prioritises evidence-based pharmaceutical medicine over Complementary and Alternative Medicine (CAM). By being dismissed as 'pseudo medicine' many aspects of CAM will similarly be under-represented in the future archaeological record.

The relative archaeological 'visibility' of western medicine and archaeologists' prioritisation of the formal instruments and tools of medical practice, is matched by the growing preoccupation

within post-Enlightenment, and particularly germ-based medicine, with 'making visible' the physical manifestation of disease and illness. Longhurst (this volume), drawing on Latour (1988; also Sismondo 2004), argues that the rise of the scientific laboratory and its technologies (such as the imaging suite, the clinic and the mortuary, Prior 2003), not only rendered the microbe visible, but also defined it. In particular, the development of moulage techniques '*functioned to reveal disease, both visually and ontologically*', and closely mirrored changing attitudes towards the spread of disease and, in particular, the '*transition from concepts such as miasma to a widespread acceptance of germ theory*'.

Moving from the instruments of medical practice to materia medica, medicinal plants, being the component of traditional medicine that have the longest history of assimilation into modern medicine, have similarly dominated attention in archaeological discourse (e.g. Hardy et al. 2012 Halberstein 2005; Day 2013; Totelin 2016). In this volume Baker, Matczak, Rice, and Currie et al. all include discussions of plant-based medicines in their articles. There has been far less consideration of animal and mineral-based medicines (although see Photos-Jones this volume) which would appear to be an oversight given the well-documented use of these materia medica in both ancient texts (e.g. see Lev 2003; Hall and Hall and Photos-Jones 2008; Miller and Sykes 2016) and anthropological literature (Morris 1998; Rekdal 1999; Rosner 1995; Ferreira et al. 2012; Alves and Rosa, eds. 2014; Costa-Neto 2005; Insoll 2011; Lev 2003)

Zooarchaeologists who have sought explicit evidence for animal-based medicines have concluded that one reason for their apparent absence in the archaeological record is that methods for converting animal remains into medicines are often destructive (Russell 2012, 392-4; Sykes 2014; Miller and Sykes 2016, and see Lev 2003 for a summary of zotherapy). For instance the KhoeSān of South Africa use powdered ostrich shell as a treatment for fever, diarrhoea and stomach pain (Low 2011). Similarly in his treatise on the medical properties of animals, the Roman author Pliny frequently called for animal remains to be ashed or powdered. As in traditional Chinese medicine (Wu et al. 2013), Pliny rated deer antler highly, suggesting that it can be powdered to cure ills from tooth ache to epilepsy (*Natural History* Book XXVII, trans. Jones 1963). Perhaps the most compelling case for archaeological evidence of zotherapy is provided by Lage (2009), who examined numerous wild mammal remains recovered from Maglemose and Ertebølle sites in Germany. These demonstrated unusual and heavy erosion on their shafts, where the bone had been smoothed away by a process that left chatter marks on the bone surface. Experimental replication of the chatter marks was successful only when a flint blade was scraped across the bone, producing a fine bone powder, which Lage (2009) suggested may have been used for medicine.

Matczak and Wojciech (this volume) use similar observations of wear-marks on fossilised belemnites to suggest that, in medieval Poland, these too may have been scraped to obtain medicinal powders. Their paper provides, therefore, one of very few examples of archaeological evidence for lithotherapeutics. A more comprehensive study of mineral medicines is provided by the work of Photos-Jones (this volume; also Hall and Photos-Jones 2008) who has been exploring the role of minerals in Galenic medicine of the Greco-Roman world. Her work integrates historical and archaeological research to reconstruct the production, distribution and consumption of lemnian earth in the ancient world. Photos-Jones demonstrates the considerable evidence for medicine that is available in the archaeological record, concluding however that what is lacking is archaeologists who are willing to search for it.

It is important to note, however, that in those societies where dietary traditions are closely bound up with medicine, it will be hard to differentiate medical practice from day-to-day consumption patterns. Indeed, for many archaeological cultures, what may seem like innocuous rubbish or domestic food waste can often be vestiges of complex interactions and belief systems. Within Indian history, for instance, the majority of cooking spices and primary ingredients including pulses and grains are also key components of Ayurvedic remedies which are only introduced if proper diet and lifestyle in keeping with one's constitution (*doṣa*) is not followed (Wujastyk 2004). It can thus be hard to distinguish archaeologically between culinary and medical applications of specific ingredients. Indian medicine is shaped by broader religio-philosophical worldviews and ontologies, particularly those governed by frameworks of purity and pollution which determine which foods and cooking methods are appropriate for specific castes and constitutions (Zimmermann 2004; Shaw 2016a). However, individual health needs and the basic quest for survival (*Ayurveda* meaning literally 'the science of longevity'), can override such ritual dispensations (Wujastyk 2004: 836-7). Whilst a focused archaeological investigation of Ayurveda remains to be undertaken, it is only in such cases when medical treatment departs from ritually determined dietary norms that we might expect to find explicit archaeological traces.

Several of the papers here demonstrate that archaeological evidence for medical practice and care may not always manifest in the obvious sense of *materia medica* or medical / surgical instruments. For example, Longhurst (this volume) in her study of an Australian Quarantine Station demonstrates that, despite being established as a centre for the control of disease, only yields a minority of archaeological remains that are explicitly medical in nature. By contrast, divergent evidence such as gravestone inscriptions and other symbols of migration and transience (e.g. suitcases) shed light on the underlying personal themes of loss, trauma and insecurity for migrants passing through the centre. On an institutional level, mail sterilisation machinery, table wares, and other items chosen on the basis of their relative potential for the

spread of disease, reveals a preoccupation with decontamination and the control of bodies and illness. Indeed, the theme of travel, movement and trade is an important thread in the archaeology of medicine both in terms of the spread of exotic materia medica as well as the threat of contagion and disease.

MEDICINE AS EXOTICA, DESIRABLE AND DANGEROUS

The potency of exotica is central to historical accounts of early medicine. Geographical distance is frequently associated with supernatural distance (Helms 1993), so healing power is deemed to increase with cultural distance (Rekdal 1999, 473). For this reason, medical interventions often utilise plants, animals and objects that are viewed as exotic, coming as they do from beyond the realm of daily practice both in terms of function and origin (Miller and Sykes 2016). For example, papers in this volume explore the significance of imported crops such as castor beans (Rice) or mustard powder (Longhurst) within colonial medical practice.

However, it is also important to note that many of these 'rare', traded, medicinal commodities begin their journey as more mundane, everyday food staples. A key example is the westward spread of rice from India to Europe (Sherratt 1999; Bakels and Jacomet 2003), initially transported as a medicinal commodity through Greek and Roman trade, and only later becoming cultivated locally in Europe following the spread of Islam and related hydrological technologies. In later periods, the westward spread of Cocoa, tea, and mustard, and spices such as black pepper, clove or nutmeg follow similar trajectories (Turner 2004; Van der Veen 2003; Van der Veen and Morales 2015; Zumbroich 2012), and whose blurred and intertwined culinary / medicinal properties impact on their archaeological identification and quantification as explicit materia medica.

Healers themselves are frequently itinerant, their powers viewed in part as being derived from an 'other-worldly' status. For example, Currie (this volume) argues that Andean healers are commonly depicted on pottery in 'otherworldly' forms, and demonstrates extensive linkages between healing and shamanistic cosmologies. Healers may also literally be travellers, bringing with them medical knowledge and materia medica from far-off lands. As Photos-Jones (this volume) mentions, Galen himself was a great traveller and collector of medical knowledge, having visited Lemnos, Cyprus and Syria to witness the production of geopharmaceuticals. Similarly, in India, wandering physicians, described by both Greek and Indian sources (Zysk 1991), were arguably connected to the early Buddhist tradition of peripatetic monks and later

institutionalised monasticism, for which medicine was one of several practical instruments for evangelism and the generation of patronage (Shaw 2013a, 2016a).

In other circumstances, sick individuals themselves must travel beyond their known realm, on pilgrimage to healing locations and shrines - in return for miracle or practical cures from disease (See Matczak and Wojciech, this volume; Talbot 2002). The act of pilgrimage is also viewed as a healing journey whereby the transition to 'other' worlds can in itself involve spiritual and physical transformation of one's usual social and personal circumstances (Shaw 2013b; Stopford 1994; Eade and Sallnow eds. 1991). However, travel also comes with dangers, as outlined by Longhurst's (this volume) study of Australian quarantine centres whose history coincided with the transition from miasma to germ theory, and which were designed to prevent the spread of disease and contagion that was associated with migration and social upheaval.

Many of the decontamination measures described by Longhurst, including quarantine and fumigation, fit within the category of preventative medicine (in ways which might today raise ethical concerns given the toxicity of the fumigants being used on what were otherwise healthy individuals). As highlighted by historical cases such as the spread of smallpox from European to native American populations and more recently by One Health and Global Health initiatives aimed at tackling conflict and climate-change related health challenges (Watts et al. 2017; Whitmee et al. 2015), globalisation and the mass movement of people has long since been connected with disease and epidemics.

The physical dangers associated with travel and inter-cultural mingling are often presented within socially and ritually proscribed frameworks, which further illuminate the importance of viewing medical beliefs within their respective worldview. For example, the Indian caste-system, shaped by laws of purity and pollution that determine who can do and eat what, meant that both travel and the medical profession were forbidden activities for high castes for fear of contamination from 'dangerous' bodies, fluids and illnesses (Zimmermann 2004). It is for this reason that wandering Buddhist monks arguably became the key vehicle for the transmission of medical knowledge and practice in ancient India (Zysk 1986, 1991; Shaw 2016a). Despite the tendency for western anthropologists (Douglas 1966, Morrison 2012, 338) to dismiss concerns for 'ritual purity' as 'displaced anxiety' of an assumed phobic or irrational nature, the physical hazards of contact with dead or sick bodies and associated precautionary measures (such as vegetarianism, or ceramic firing and glazing techniques) within a pre-refrigeration, pre-germ theory context, are not that dissimilar to those presented in Longhurst's (this volume) 19th / 20th century Australian case-study.

Longhurst discusses how imported materials were graded according to hierarchies of contaminability, shaped by variables such as permeability, animal origin, or susceptibility to decay. This meant that a Wedgwood dinner plate was not simply a decorative piece of tableware but also part of the machinery for repelling disease. Such examples raise interesting questions as to how pre-modern religio-medical practices aimed at regulating health and preventing disease intersect with and contradict modern practices and beliefs about cleanliness / health, and dirt / contagion (Shaw 2016a).

MEDICAL ADMINISTRATION AND THE BODY POLITIC: MEDICINE AS INSTRUMENT OF STATE

A key question that runs through some of the papers in this volume is to what degree medical knowledge, its transference and application, can be related to (official v. unofficial) structures of power and authority? Medical knowledge and practice is often closely linked with state administration, as discussed frequently in discourse on the 'body politic' (Kraakauer 1992). This is illustrated by historical examples ranging from national vaccination programmes to state-sanctioned medical abuse of disenfranchised / vulnerable groups, including forced sterilisations, euthanasia, obstetric violence (Borges 2018), and drug malpractice. Further, perceptions of 'acceptable' ('evidence-based' pharmaceutical) medicine v. 'quack' (CAM) medicine are enshrined in state-level legislature and mirror the long-standing divide between physician and apothecary-based medical care in medieval Europe. The prime example of 'medicine' as instrument of state, including its administration of justice and law, is the problematic role of the medical profession and pharmaceutical industry in the implementation of corporal punishment.

The theme of medicine and inequality is explored by Photo-Jones's (this volume) study of Greco-Roman *pharmakopolai* and the *pharmakotrivai*, who were involved in the sale and production of drugs and pigments respectively. She suggests that these workers were of low social status and that one individual named as Moschion in the Demosthenes' *Against Olympiodorus* (13-15) was likely a slave. This is in sharp contrast to the high status of the physicians themselves.

Other contributors (Currie et al., Rice, Camp and Reifschneider) to this volume discuss additional evidence for the inequalities of healthcare. Camp discusses the treatment of prisoners at a World War II internment camp, examining the United States of America's management of political prisoners' health through the prism of vision and eye-related objects. Camp discusses the 'historical and biological situatedness of senses' and their politicization through a form of 'sensorial inequality' amongst the prisoner:non-prisoner population, whereby 'senses could be muted, made pungent (in the case of smells), denied to people as a

subtle or overt strategy of war, social marginalization, and discrimination'. Both Reifschneider, and Longhurst describe colonial hospitals as places of state control and containment, with Reifschneider arguing that 'the struggle for power over the health of enslaved people was a site of contestation among the administration, planters and enslaved people themselves'. She examines the effects of centralised, state-administered healthcare of enslaved and colonised populations within the archaeological record of a 19th-century colonial plantation hospital in the Danish West Indies, interrogating how '*people negotiate power relationships between the body and the state. Healthcare is a politicized practice and enslaved people at the hospital contended with targeted, interventionist models of healthcare (and possibly neglect) by creating alternative modes of healing*'. Despite the hospital's top-down institutional structure, there was a distinct lack of evidence for overtly medical artefacts and specialised diets in the archaeological record, which might suggest neglect by plantation managers and doctors. However, the prevalence of locally available materials suggest that local nurses drew on native medical plants and animal resources to treat their patients. Whilst compensating for a lack of professional care, Reifschneider suggests that this may also have been a form of active resistance to European medical practice (Sheridan 1985; Wilkie 1996) that encouraged 'adaptive and strategic models of care which fell outside the purview of colonial healthcare', highlighting further the need to move away from Western, clinical, frameworks of healthcare in order to better illuminate the varied way of healing represented in the archaeological record.

Further evidence for resistance to colonial medical practices is discussed by Rice (this volume) in relation to a Bethlehemite Order monastic hospital attached to a colonial wine estate in Peru. A mixed archaeobotanical assemblage from the site attests to a 'pick-and-mix' approach to medical traditions in ways that mirror 'medical' models of religious change (Shaw 2013a), whereby the workers made use of indigenous healing items such as datura, molle berries and soapberry, whilst at the same time cultivating imported medical crops such as castor bean, and grapes for wine and brandy.

RELIGION AND MEDICINE: DEVOLVED MODELS OF MEDICAL ADMINISTRATION

Medical practice has long been linked to institutionalised religious settings, such as in cases of monasteries functioning as hospitals. Similar to Rice's findings for the monastic hospital in Peru, Matczak and Wojciech's (this volume) study of 10th-century Poland, highlighted that magical therapeutics were merged with those brought by the Order of St Benedict. Thus the 'scientific' medicine of the European colonists was explicitly aligned with Christian theology. Indeed,

indigenous medical substances and practices were frequently viewed by colonial religious authorities as 'the work of sorcerers, heretics, magicians, and charlatans in league with the devil' (Mendoza 2003, 229). As outlined by Rice, the many early ecclesiastical campaigns to root out 'idolatrous' components of indigenous religions resulted in the deaths of diviners and healers practicing herbal medicine associated with these traditional magico-religious beliefs (Gareis 1999).

A possibly more devolved function was performed by early Buddhist monastic establishments in India (late centuries BC onwards) whose involvement with medical practice and dissemination (Zysk 1991) formed part of a Buddhist worldview regarding the omnipresence of human suffering and the means of its alleviation through the correction of human action and interaction with the world (Shaw 2013a). Early Buddhist monastic involvement with medicine, together with other practical functions including land and water management, can be regarded as part of a community-based model of healing and tackling socio-ecological challenges (Shaw 2016a), although disconnection from centralised state power was not necessarily constant. Parallels can be drawn with recent calls from public health theorists who stress the element of community responsibility as a tool for tackling current health challenges (Deprez and Thomas 2016). Similarly arguments within contemporary and future disaster management discourse emphasise the importance of engaging with religion and associated worldviews for tackling the socio-medical fallout of environmental stress (Chester 2005; Hulme 2010).

FUTURE AVENUES

Archaeology is traditionally considered to be a backward-looking discipline, concerned mainly with reconstructing the actions of ancient societies. Certainly, this volume does provide much new archaeological information concerning past cultures - from Neanderthals to early modern prisoners of war. However, what emerges from these papers, is that diachronic approaches to medicine and healthcare have considerably more potential, not only for understanding ancient worldviews but also for contextualising and mitigating modern problems of global health. Papers in this volume have demonstrated that despite attempts by modern medicine to replace or discredit traditional medical knowledge and practice, there is ample archaeological evidence, for local resistance to imported structures, or for a 'pick and mix' attitude to *materia medica* and healing practices that best suited the illness in question. As discussed by Currie et al., Andean health beliefs and practices can inform 'inter-cultural' healthcare models in ways that help to avoid the imposition of European medical frameworks based on the notion of unilinear 'development' and improvement. Such an approach can also contribute to better protection of living traditions as 'intangible cultural heritage', in keeping with the recommendations of the 2003 UNESCO Convention for the Safeguarding of Intangible Cultural Heritage.

The preservation of traditional systems of healthcare is important not only in terms of heritage conservation but also for safeguarding Traditional Ecological Knowledge (TEK). TEK is increasingly being recognised as a source for the development of new remedies (Reyes-García, 2010) although such initiatives raise ethical questions of intellectual property and ensuring that benefits are returned to those from whom the knowledge has been obtained (Bodeker 2003). Considerable work is being undertaken to reformulate remedies from Traditional Chinese Medicine (TCM) (Xu et al. 2013; Ehrman et al. 2010), and Ayurveda (e.g. Prasad and Tyagi 2015; Ammon and Müller 1985). For example, Biradar et al. (2008) successfully prepared and tested a non-specific antimicrobial following an Ayurvedic recipe for *Triphala Mashi*, a herbal formulation derived from dried fruits. The growing emphasis on ethnopharmacology in drug development is reflected by increasing numbers of traditional medicine research centres at UK universities together with specialised journals and research associations (e.g., the recently established, Good Practice in Traditional Chinese Medicine Research Association - <http://www.gp-tcm.org>). Such developments attest to the potential of integrated approaches to traditional and modern drug development, although the overarching emphasis on the 'rationalisation' of traditional medical knowledge through the isolation and structural determination of 'novel' bioactive compounds (Mohd et al. 2013) highlights ongoing tensions and incompatibilities between underlying medical epistemologies and worldviews. As discussed by Reyes-García (2010), it is important to acknowledge the 'holistic nature of traditional knowledge systems [that help us to] understand [a] plant's efficacy in its cultural context', as despite modern clinical interest in the individual active compounds of indigenous pharmacopoeias, such compounds are rarely isolated or act alone in indigenous healing systems.

The drive for the development of new antimicrobials is being prompted by the growing 'wicked' problem of antimicrobial resistance. In 2017, Gandra et al. published their scoping report for India which sets out the factors driving AMR resistance, arguing that these forces of evolution are environmental, economic, cultural, interconnected, and multi-scalar, and that they cannot be tackled by any single discipline in isolation. Archaeology has the potential to help model some of these factors but also to explore, in deep time, and ideally in collaboration with historical scholarship, what antimicrobial medicines people used prior to the age of antibiotics. Following the aforementioned examples of the reformulation of Ayurvedic compounds, explorations of 'ancientbiotics' are now being undertaken for Anglo-Saxon remedies, such as Harrison et al.'s (2015) research concerning the eye-infection remedy in Bald's Leechbook (a rare example of research on ocular health - see Camp this volume). Similarly, a key aim of Photo-Jones's (this volume and 2016) study of mineral medicinals and their biomedical action is to translate 'empirical observations and practices in use for over two millennia into scientific

language that could be meaningful today', with particular emphasis on the therapeutic opportunities presented by the attested antibacterial properties of Greco-Roman Alum-based minerals and their microbiomes.

This latter emphasis is particularly noteworthy given that the health implications of the microbiome have only very recently been incorporated into mainstream biomedical research, with archaeological enquiries following close behind (Schnorr et al. 2016).

The Enlightenment, with the rise of modern Western science, is often cited as responsible for the demise of humoral principles and for creating the separation between humans and animals that led to the subjugation and objectification of the latter (Bulliet 2005: 45; Ingold 1994; Thomas 1983). However, to some extent, recent advances in archaeological science are increasingly enabling human-animal-environment interactions and elemental transfers at the biomolecular level. For instance, in common with humoral theory, isotopic analyses seek to understand, quite literally, how elemental composition is transferred from the landscape and from one organism to another. Similarly, increased integration between Humanities and Biomedical-led research has broadened scholarly understanding of the intertwined relationships between environment, diet and health, and also illuminated future directions in disease aetiology and treatment. For example, impacts of the global shift from hunter-gatherer lifeways to domesticated agriculture which left people more susceptible to climatic instability and crop failure are of increasing relevance to medical understanding of diabetes epidemiology (Wells et al. 2016) and gut microbiome health (Schnorr et al. 2016). Such research draws on evidence for the negative health impact of consequent famine:feast cycles in India as documented in skeletal records (Walimbe 1998), with additional impacts from the shift from hunter-gatherer protein-rich diets to carbohydrate-rich, protein-deficient cereal-based diets of Chalcolithic agriculturalists (Cohen 1977; Kajale 1991; Mummert et al. 2011).

The potential of ancient medicine to inform modern practice can be viewed as part of a growing trend across the Humanities-Sciences spectrum to highlight the capacity of deep-time human-animal-environmental health entanglements for influencing responses to contemporary and future problems. By highlighting the impact of Humanities-led collaborations on climate change, environmental sciences and environmental health studies, the chances of initiating positive community change in personal and environmental practice is increased. For instance, understanding how worldviews (including those shaped by explicitly religio-philosophical theologies) shape conceptualisations of nature and its care can help to understand broader human-animal-environment relationships that in turn shape major patterns of health and disease. Such a recognition is particularly pertinent in the age of the Anthropocene and the

increasing scholarly interest in its deep history of human-animal-environmental interaction (Braje 2016).

Such deep-time perspectives on human:animal:environmental interactions can usefully be related to major new strands of environmental medicine (Shaw 2016a,b) which demonstrate how our synthetically altered environment is changing human and non-human animals at an intergenerational level through epigenetic, genetic and endocrine disruption (DellaValle 2016; Parry and Dupré 2010; Dupré 2016), and by extension that healing of the human body needs to go hand in hand with healing of the environment (Shaw 2016a,b). The epigenetic model introduces a crucial medical perspective to the growing human:environment 'entanglement' (Hodder 2012) theme in the social sciences, and intersects closely with new sustainable development models (United Nations 2015), and related medical initiatives such as Planetary Health and One Health agendas (Watts et al. 2017; Whitmee et al. 2015) that recognise the health impact of our global environmental / climate change crisis (Shaw 2016b).

In many ways the One Health Initiative, through its emphasis on human-animal-environment interactions can be viewed as a return to an elemental/humoral-based approach to global health challenges and epidemiology. The latter, as discussed by Baker (this volume) in relation to Roman concepts of health and air quality, however, are framed predominantly from the perspective of wellbeing rather than from the viewpoint of toxicology and environmental health. Such discussions can usefully be situated within historical scholarship on gardens and 'pleasure groves' in antiquity as places of healing (Ali 2003) as well as modern public health discourse on ecotherapy, and 'nature'-and-wellbeing (Burls 2007), with the primary emphasis being on the psychological, sensory and experiential benefits of nature immersion, especially in childhood. Further, the less pleasant sensory experiences that Baker alludes to in her discussion of 'bad' or putrid smells have an obvious bearing on modern environmental health and toxicological discourse which has demonstrated that air pollutants are not just unpleasant but can have a profound impact on physical health. For example, recent biomedical research (Genius, 2012; Mostafalou and Abdollahi, 2013) highlights the mutual link between major chronic illness and both outdoor and indoor air pollution, the latter sources of which including plasters and paints, wall and floor materials, poor ventilation, and damp and mould, lend themselves well to future avenues of archaeological enquiry.

By stressing the interconnectivity of human-animal-environmental health, the epigenetic model is also instructive for encouraging greater integration between environmental health, environmental ethics, and bioethics (Shaw 2016a,b; Lee 2017; Macer 2017), and for increasing the scope for bringing 'green' agendas into mainstream political activism. The concept of religio-medical worldviews here is particularly important here, for whilst environmentalism has

been viewed as a form of 'secular religion' (Latour 2013), in many contexts, it is explicitly *religious* worldviews that are the primary shapers of attitudes regarding empirical knowledge about humans' place in the world, and for codifying frameworks of purity or cleanliness versus pollution or dirt, or of harmful versus safe human:non-human relationships. By contrast, in secular contexts it is often scientifically driven government legislation that provides the last word for determining beliefs about environmental health, disease aetiology, and related consumption and lifestyle choices that impact on global human health as well as environmental and climate patterns (Holm et al. 2015). The question of how traditional definitions of sacred / pure space correspond with modern medical notions of cleanliness or 'hygiene' is thus one that deserves further archaeological investigation. Such an approach would allow for the testing of what are sometimes over-idealised accounts of the potential for religious attitudes towards health and environment to shape modern responses to both medical and environmental challenges (Shaw 2016a).

Other future challenges include developing archaeologies of care and reframing perceptions of disability and associated stigma in keeping with the recognition of the 'social model' of illness within the broader Medical Humanities. Archaeology, with its traditional reliance on a narrowly medical model of illness, has been slow to incorporate such shifts, with the result that studies of disability in antiquity rarely go beyond the strictly physical manifestations of visible injury or illness (Cross 2007). An exception is Spikins' (this volume) discussion of Neanderthal healthcare, in which the element of social bonding is seen as a key factor in the long-term survival of individuals with visible injuries. The very similarity of Neanderthal healthcare to that of later periods has important implications, that organized, knowledgeable and caring healthcare is not unique to our species but rather has a long evolutionary history. Healthcare provisioning is likely to have been significant in reducing mortality and ameliorating risks in resource acquisition far into the distant past.

Others have highlighted the social stigmatisation of disability and illness in antiquity (Cross 2007; Hubert 2010), with a particular emphasis on conditions such as leprosy that manifest in very visible disfiguration (Schug 2016). However, in the absence of a clearly defined social model of illness within archaeology, there are unique challenges when it comes to the archaeological identification of 'invisible' disabilities whose lack of obvious disfiguration has been shown to often *increase* levels of social rejection, humiliation, disapproval, and disbelief towards the sufferer (Davis 2005). Such problems are compounded in cases of emergent illnesses whose aetiological basis often escapes biomedical understanding or diagnostic capabilities at particular points in time. Despite the hugely destructive force of chronic pain (Scarry 1985), lack of medical consensus regarding associated biomarkers means that sufferers often fail to receive the level of healthcare that they need (Davis 2005). Archaeological

identification of such conditions is likely to require looking beyond skeletal deformities, *materia medica* and medical instruments, to broader evidence for social care, neglect or exclusion. In this respect the archaeology of medicine could benefit from greater engagement with emerging discourse on chronic illness and pain within the fields of historical disability studies, history of emotions, and history of the senses (Linker 2013, and papers delivered at the UCL / Society for the Social History of Medicine's 2017 conference on 'Chronic Pain in the Middle Ages': <https://www.ucl.ac.uk/institute-of-advanced-studies/events/2017/sep/why-my-pain-perpetual-jer-1518-chronic-pain-middle-ages>).

The social model of illness is particularly important for the archaeology of medicine as it provides caution against imposing modern aetiological frameworks to archaeological indicators of past illnesses that were made sense of within very different epistemological frameworks. Thus, 'diagnosing' illness today from skeletal remains does little to illuminate the social arena of medicine or healthcare in the past unless accompanied by knowledge of the contemporary medical as well as social concepts of disease aetiology. Conversely, a historical perspective on changing medical interpretations of illness has potential to inform better community and professional responses to emergent diseases today, and to encourage the suspension of disbelief and stigmatisation whilst 'scientific' understanding is still nascent, against the tendency throughout the history of medicine for there to be prolonged periods of resistance to new paradigms that later become established dogma (Genuis 2012; Williams 2007).

This discussion also raises questions about official versus alternative health beliefs and medical frameworks of treatment especially in cases of conditions that escape mainstream diagnosis or recognition, and serve to remind archaeologists that medical knowledge and practice at any point of time or place is rarely homogenous. Medical practice as an instrument of official, state-level power and control over bodies, especially those of the poor and disenfranchised, has been highlighted in several of the papers in this volume (Rice, Reifschneider, Camp), as have frameworks of resistance to mainstream medical powers, and inequities in access to and quality of healthcare. Given the long-standing tensions between Physicians and Apothecaries in medieval Europe, and similar tensions in modern settings between pharmaceutical medicine and CAM, as well as ongoing inequities in healthcare access, similar heterogeneities are likely to have existed in every historical context. Incorporating these less visible conditions, as well as marginal, dissenting or even covert treatments, into a socially-integrated, deep-time understanding of medicine and the care of humans as well as animals and the broader environment, remains a challenge for future archaeological endeavours.

REFERENCES

Ahmad, J., and H.A. Qadeer, 1998: *Unani. The science of Graeco-Arabic medicine*, New Delhi.

Adler C.J., K. Dobney, L.S. Weyrich, J. Kaidonis, A.W. Walker, W. Haak, C.J.A. Bradshaw, G. Townsend, A. Soltysiak, K.W. Alt, J. Parkhill, J. and A. Cooper, 2013. "Sequencing Ancient Calcified Dental Plaque shows Changes in Oral Microbiota with Dietary shifts of the Neolithic and Industrial Revolutions." *Nature Genetics* 45: 450–455. e1. [doi:10.1038/ng.2536](https://doi.org/10.1038/ng.2536).

Afif, N., S. Bhayro, G. Kessel, P.E. Pormann, W.I. Sellers, and N. Smelova. 2018. "The Syriac Galen Palimpsest: A Tale of Two Texts." *Manuscript Studies* 3(1): 110–154. DOI: 10.1353/mns.2018.0005

Ali, G. 2003. "Gardens in Early Indian Court Life." *Studies in History* 19 (2): 221–252. doi:10.1177/025764300301900204.

Alves, R.R.N. and I.L. Rosa. eds. 2014. *Animals in Traditional Folk Medicine*. Berlin: Springer.

Arikha, N. 2007. *Passions and Tempers: A History of the Humours*. New York: Harper Collins.

Ammon, H.P., and A.B. Müller. 1985. "Forskolin: From an Ayurvedic Remedy to a Modern Agent." *Planta Medica* 51 (06): 473-477.

Anderson Jr., E.N. 1987. Why is Humoral Medicine So Popular? *Social Science Medicine* 25:331. DOI: 10.1016/0277-9536(87)90271-1

Bakels, C., and S. Jacomet, 2003 "Access to Luxury foods in Central Europe during the Roman Period: The Archaeobotanical Evidence." *World Archaeology* 34 (3): 542–557.

Baker, P. 2004. "Roman Medical Instruments: Archaeological Interpretations of their Possible 'Non-functional' Uses." *Social History of Medicine* 17(1): 3-21.

Baker, P.A. 2013. *The Archaeology of Medicine in the Greco-Roman World*. Cambridge: Cambridge University Press.

Bastien, J. W. 1981. "Metaphorical Relations between Sickness, Society, and Land in a Qollahauya Ritual." In *Health in the Andes*, edited by J. W. Bastien and J. M. Donahue, 19–37. Washington: American Anthropological Association.

Bastien, J. W. 1985. "Qollahuaya–Andean Body Concepts: A Topographical-Hydraulic Model of Physiology." *American Anthropologist* 87 (3): 595–611. doi:10.1525/aa.1985.87.issue-3.

Becker, M.J. 2014. "Dentistry in Ancient Rome: Direct Evidence for Extractions Based on the Teeth from Excavations at the Temple of Castor and Pollux in the Roman Forum." *International Journal of Anthropology* 29(4): 209-226.

Bernardini, F., C. Tuniz, A. Coppa, L. Mancini, D. Dreossi, D. Eichert, G. Turco, M. Biasotto, F. Terrasi, N. De Cesare, and Q. Hua. 2012. "Beeswax as Dental Filling on a Neolithic Human Tooth." *PLoS One*, 7(9): p.e44904.

Biradar, Y.S., S. Jagatap, K.R. Khandelwal, and S.S. Singhania. 2008. "Exploring of Antimicrobial Activity of Triphala Mashī - An Ayurvedic Formulation." *Evidence-based Complementary and Alternative Medicine* 5(1): 107-113.

Bodeker, G., 2003. "Traditional Medical Knowledge, Intellectual Property Rights & (and) Benefit Sharing". *Cardozo Journal of International and Comparative Law* 11: 785-814

Borges, M.T.R. 2018. "A Violent Birth: Reframing Coerced Procedures during Childbirth as Obstetric Violence." *Duke Law Journal* 67: 827-862.

Braje, T. J. 2016. "Evaluating the Anthropocene: Is There Something Useful about a Geological Epoch of Humans?" *Antiquity* 90: 504–512. doi:10.15184/aqy.2016.32.

Büchler, A. 2012. "Regulating the Sacred. Organ Donation and Transplantation: Autonomy and Integrity of the Person or Social Responsibility of the Body". The Joseph and Gwendolyn Straus Institute of the Advanced Study of Law and Justice. Working Paper 01/12.
www.law.nyu.edu/sites/default/files/siwp/WP1Buchler.pdf

Bulliet, R.W. 2005. *Hunters, Herder, and Hamburgers: e Past and Future of Human-Animal Relationships*, New York: Columbia University Press.

Burkert, W. 1995. *The Orientalizing Revolution: Near Eastern Influence on Greek Culture in the Early Archaic Age*. Cambridge, MA: Harvard University Press.

Burls, A. 2007. "People and Green Spaces: Promoting Public Health and Mental Well-Being through Ecotherapy." *Journal of Public Mental Health* 6 (3): 24–39.
doi:10.1108/17465729200700018.

Chester, D. K. 2005. "Theology and Disaster Studies: The Need for Dialogue." *Journal of Volcanology and Geothermal Research* 146 (4), 319–28.

Cohen, M. N. 1977. *The Food Crisis in Prehistory: Overpopulation and the Origins of Agriculture*. New Haven: Yale University Press.

Costa-Neto, E.M. 2004. Implications and applications of folk zootherapy in the state of Bahia, Northeastern Brazil. *Sustainable Development*, 12:161. DOI: 10.1002/sd.234

Cross, M. 2007. "Accessing the Inaccessible: Disability and Archaeology." In *The Archaeology of Identities: A Reader*, edited by T. Insoll, 179-194. London: Routledge.

Davis, N. A., 2005. "Invisible Disability." *Ethics* 116 (1): 153-213.
<https://doi.org/10.1086/453151>

Day, J. 2013. "Botany Meets Archaeology: People and Plants in the Past." *Journal of Experimental Botany* 64(18): 5805-5816.

DellaValle, C. 2016. "The Pollution in People: Cancer-causing Chemicals in Americans' Bodies." Environmental Working Group Original Research. <http://www.ewg.org/cancer/the-pollution-in-people.php>.

Deprez, R., and R. Thomas. 2016. "Population Health Improvement: It's Up to the Community – Not the Healthcare System." *Maine Policy Review* 25 (2): 44–52.

Douglas, M. 1966. *Purity and Danger: An Analysis of the Concepts of Pollution and Taboo*. London: Routledge and Kegan Paul.

Dupré, J. 2016. "A Postgenomic Perspective on Sex and Gender." In *How Biology Shapes Philosophy: New Foundations for Naturalism*, edited by D. L. Smith, 227–46. Cambridge: Cambridge University Press.

Eade, J. and S. Sallnow. eds. 1991. *Contesting the Sacred: The Anthropology of Christian*

Pilgrimage. London: Routledge.

Ehrman, T.M., D.J. Barlow and P.J. Hi, 2010. "In-silico Search for Multi-target Anti-inflammatories in Chinese Herbs and Formulas." *Bioorganic and Medicinal Chemistry* 18(6): 2204-18.

Elmer, P. 2004. *The Healing Arts: Health, Disease and Society in Europe 1500-1800*. Manchester: Manchester University Press.

Ferreira, F.S., U.P. Albuquerque, H.D.M. Coutinho, W.O. Almedia and R.R.N. Alves. 2012. The trade in medicinal animals in Northeastern Brazil. *Evidence Based Complementary and Alternative Medicine* 2012:1. DOI: 10.1155/2012/126938

Foster, G.M., 1994. *Hippocrates' Latin American Legacy: Humoral medicine in the New World*. Reading: Taylor and Francis.

Gandra, S., J. Joshi, A. Trett, A. Sankhil Lamkang, and R. Laxminarayan. 2017. *Scoping Report on Antimicrobial Resistance in India*. Washington, DC: Center for Disease Dynamics, Economics and Policy.

Gareis, I. 1999. "Repression and Cultural Change: The 'Extirpation of Idolatry' in Colonial Peru." In *Spiritual Encounters: Interactions between Christianity and Native Religions in Colonial America*, edited by N. Griffiths and F. Cervantes, 230–254. Lincoln: University of Nebraska Press.

Genuis, S. J. 2012. "What's out there making us sick?" *Journal of Environmental and Public Health*, art. no. 605137, 10 pp. doi:10.1155/2012/605137.

Goody, J. 1975. Religion, Social change, and the Sociology of Conversion. In *Changing Social Structure in Ghana*, edited by J. Goody, 91-106. London: International African Institute.

Grauer, A.L. ed. 2012. *A Companion to Paleopathology*. London: John Wiley & Sons.

Halberstein, R.A. 2005. "Medicinal Plants: Historical and Cross-cultural Usage Patterns. *Annals of Epidemiology* 15(9): 686-699.

Hall, A.J., and E. Photos-Jones. 2008. "Accessing Past Beliefs and Practices: The Case of Lemnian Earth." *Archaeometry* 50(6): 1034-1049.

Hardy, K., S. Buckley, M.J. Collins, A. Estalrich, D. Brothwell, L. Copeland, A. García-Taberner, S. García-Vargas, M. de la Rasilla, C. Lalueza-Fox, and R. Huguet. 2012. "Neanderthal Medics? Evidence for Food, Cooking, and Medicinal Plants Entrapped in Dental Calculus." *Naturwissenschaften* 99(8): 617-626.

Harrison, F., A.E. Roberts, R. Gabriliska, K.P. Rumbaugh, C. Lee, and S.P. Diggle. 2015. "A 1,000-year-old Antimicrobial Remedy with Antistaphylococcal Activity." *MBio* 6(4): e01129-15.

Hendy, J., C. Warinner, A. Bouwman, M.J. Collins, S. Fiddyment, R. Fischer, R. Hagan, C.A. Hofman, M. Holst, E. Chaves, and L. Klaus. 2018. "Proteomic Evidence of Dietary Sources in Ancient Dental Calculus." *Proceedings of the Royal Society B* 285(1883): 20180977.

Hodder, I. 2012. *Entangled: An Archaeology of the Relationships between Humans and Things*. Oxford: Wiley-Blackwell.

Holm, P., et al. 2015. "Humanities for the Environment: A Manifesto for Research and Action." *Humanities* 4:977-992.

Horden, P. and E. Hsu. eds. 2013. *The Body in Balance: Humoral Medicines in Practice*. Vol. 13. New York: Berghahn Books.

Hubert, J. 2010. "Introduction: The Complexity of Boundedness and Exclusion." In *Madness, Disability and Social Exclusion: The Archaeology and Anthropology of 'Difference'*, edited by J. Hubert. One World Archaeology, vol. 40, 1-8. London: Routledge.

Hulme, M. 2010. "The Idea of Climate Change: Exploring Complexity, Plurality and Opportunity." *Gaia* 19: 171-4.

Ingold, T. 1994. 'From Trust to Domination: An Alternative History of Human-animal Relations', in A. Manning and J. Serpell (eds), *Animals and Human Society: Changing Perspectives*, London: Routledge.

Insoll, T. 2011. "Substance and materiality? The archaeology of Talensi medicine shrines and medicinal practices". *Anthropology and Medicine* 18:181. DOI: 10.1080/13648470.2011.591196

Jackson, R. 1997. "An Ancient British Medical Kit from Stanway, Essex." *The Lancet* 350 (9089): 1471-1473.

Jones, R., H. Miller, and N. Sykes. 2016. "Is it Time for an Elemental and Humoral (Re) turn in Archaeology?" *Archaeological Dialogues* 23(2): 175-192.

Kajale, M. D. 1991. "Current Status of Indian Palaeoethnobotany: Introduced and Indigenous Food Plants with a Discussion of the Historical and Evolutionary Development of Indian Agriculture and Agricultural Systems in General." In *New Light on Farming: Recent Developments in Palaeoethnobotany*, edited by C. Renfrew, 155–190. Edinburgh: Edinburgh University Press.

Krakauer E. 1992. "On Medicine and Politics." *The Yale Journal of Biology and Medicine* 65(3): 243-9.

Lage, W. 2009. "Schlei noch versus Schabbahnknochen: Untersuchungen zur Verwendung steinzeitlicher Langknochen von Großsäugern mit konkaven Arbeitsbahnen", *Schriften des Naturwissenschaftlichen Vereins für Schleswig-Holstein*, 71: 26–40.

Latour, B. 1988. *The Pasteurization of France*. Cambridge, Mass: Harvard University Press.

Latour, B. 2013. "Facing Gaia: A New Enquiry into Natural Religion." The Gifford Lectures, Edinburgh. <https://www.ed.ac.uk/arts-humanities-soc-sci/news-events/lectures/gifford-lectures/archive/series-2012-2013/bruno-latour> (accessed 21 June 2018).

Lee, L. M. 2017. "A Bridge Back to the Future: Public Health Ethics, Bioethics, and Environmental Ethics." *American Journal of Bioethics* 17 (9): 5–12.

Lev, E. 2003. "Traditional healing with animals (zootherapy): medieval to present-day Levantine practice." *Journal of Ethnopharmacology* 85:107. DOI: 10.1016/S0378-8741(02)00377-X

Linker, B. 2013. "On the Borderland of Medical and Disability History: A Survey of the Fields." *Bulletin of the History of Medicine* 87(4): 499-535. [10.1353/bhm.2013.0074](https://doi.org/10.1353/bhm.2013.0074)

Low, C. 2011. "Birds and KhoeSān: Linking Spirits and Healing with Day-to-day Life." *Africa*, 81(2): 295-313.

Macer, D. R. J. 2017. "We Can and Must Rebuild the Bridges of Interdisciplinary Bioethics." *American Journal of Bioethics* 17 (9): 1–4.

Malinar, A. 2014. "Sensory Perception and Notions of the Senses in Sāṃkhya Philosophy." In *Exploring the Senses: Asian and European Perspectives on Ritual and Performativity*, edited by A. Michaels and C. Wulf, 34–51. London: Routledge.

Malinar, A. 2016. "Notions of 'Productive Matter' and the Classification of Beings in Indian Philosophy." Paper delivered at Human: Non-Human:Bodies, Things, and Matter across Asia and Europe, URPP Asia and Europe Conference, University of Zurich, October 6–8.

Mendoza, R. G. 2003. "Lords of the Medicine Bag: Medical Science and Traditional Practice in Ancient Peru and South America." In *Medicine across Cultures: History and Practice of Medicine in Non-Western Cultures*, edited by H. Selin, 225–257. New York: Kluwer Academic Publishers. <https://www.satanas.info/wp-content/cache/mendeley-file-cache/5952c9cd-fd44-32e9-baff-4d24ed966dfd.pdf>

Messer, E. 1987. "The hot and cold in Mesoamerican indigenous and Hispanicized thought." *Social Science & Medicine* 25(4): 339–46.

Miller, H., and N. Sykes. 2016. "Zootherapy in Archaeology: The Case of the Fallow Deer (*Dama dama dama*)." *Journal of Ethnobiology* 36(2): 257-276.

Mohd, F.F., A. Koutsoukas, R. Lowe, K. Joshi, T.P. Fan, R.C. Glen, and A. Bender, 2013. "Chemogenomics approaches to rationalizing the mode-of-action of traditional Chinese and Ayurvedic medicine." *Journal of Chemical Information and Modelling* 53(3):661-73. doi: 10.1021/ci3005513.

Mogle, P., and J. Zias. 1995. "Trephination as a Possible Treatment for Scurvy in a Middle Bronze age (ca. 2200 BC) Skeleton." *International Journal of Osteoarchaeology* 5 (1): 77-81.

Morris, B. 1998. *The Power of Animals: an Ethnography*. Oxford: Berg.

Morrison, K. D. 2012. "Great Transformations: On the Archaeology of Cooking." In *The Menial Art of Cooking*, edited by S. R. Graff and E. Rodriguez-Allegria, 231–244. Denver: University Press of Colorado.

Mostafalou, S. and M. Abdollahi. 2013. "Pesticides and Human Chronic Diseases: Evidences, Mechanisms, and Perspectives." *Toxicology and Applied Pharmacology* 268: 157–77.

Mummert, A., E. Esche, J. Robinson, and G. J. Armelagos. 2011. "Stature and Robusticity during the Agricultural Transition: Evidence from the Bioarchaeological Record." *Economics and Human Biology* 9 (3): 284–301. doi:10.1016/j.ehb.2011.03.004.

Parry, S. and J. Dupré. 2010. *Nature After the Genome*. Oxford: Wiley-Blackwell.

Peel, J.D.Y. 1968. "Syncretism and Religious Change." *Comparative Studies in Society and History* 10: 121–41.

Photos-Jones, E., C. Edwards, F. Häner, L. Lawton, C. Keane, A. Leanord, and V. Perdikatsis. 2017. "Archaeological Medicinal Earths as Antibacterial Agents: The Case of the Basel Lemnian Sphragides." *Geological Society, London, Special Publications* 452: SP452-6.

Pliny. *Natural History, Volume VIII: Books 28-32*. Translated by W.H.S. Jones 1963. Loeb Classical Library 418. Cambridge, MA: Harvard University Press.

Pormann, P.E., and E. Selove. 2017. "Two New Texts on Medicine and Natural Philosophy by Abū Bakr al-Rāzī." *Journal of the American Oriental Society* 137(2): 279-299. DOI: 10.7817/jameroriesoci.137.2.0279

Powell, L., W. Southwell-Wright, and R. Gowland. 2017. *Care in the Past: Archaeological and Interdisciplinary Perspectives*. Oxford: Oxbow.

Prasad, S., and A.K. Tyagi. 2015. "Traditional Medicine: The Goldmine for Modern Drugs." *Advanced Techniques in Biology and Medicine* 3: e108. doi: 10.4172/2379-1764.1000e108

Prior, L. 2003. *Using Documents in Social Research*. London: Sage Publications.

Rekdal, O.B. 1999. "Cross-cultural Healing in East African Ethnography." *Medical Anthropology Quarterly* 13:458-482. <http://www.jstor.org/stable/649559>

Reyes-García, V. 2010. "The Relevance of Traditional Knowledge Systems for Ethnopharmacological Research: Theoretical and Methodological Contributions." *Journal of Ethnobiology and Ethnomedicine* 6(1): 32. DOI:[10.1186/1746-4269-6-32](https://doi.org/10.1186/1746-4269-6-32)

Roberts, C.A., and K. Manchester. 2007. *The Archaeology of Disease*. New York: Cornell University Press.

Rosner, F. 1995. *Medicine in the Bible and the Talmud: selections from classical Jewish sources*. New Jersey: KTVA Publishing House.

Russell, N. 2012. *Social Zooarchaeology: Humans and animals in Prehistory*. Cambridge University Press, Cambridge.

Scarry, E. 1985. *The Body in Pain: the Making and Unmaking of the World*. Oxford: Oxford University Press.

Schnorr, S., K. Sankaranarayanan, C. M. Lewis, and C. Warinner. 2016. "Insights into Human Evolution from Ancient and Contemporary Microbiome Studies." *Current Opinion in Genetics and Development* 41: 14–26. doi:10.1016/j.gde.2016.07.003.

Schug, G. R., 2016. "Begotten of Corruption? Bioarchaeology and "Othering" of Leprosy in South Asia." *International Journal of Paleopathology* 16:1-9.
<https://doi.org/10.1016/j.ijpp.2016.09.002>

Scully, T., 1995: *The Art of Cooking in the Middle Ages*. Woodbridge: Boydell.

Shaw, J. 2013a. "Archaeologies of Buddhist Propagation in Ancient India: 'Ritual' and 'Practical' Models of Religious Change." *World Archaeology* 45 (1): 83–108.
doi:10.1080/00438243.2013.778132

Shaw, J. 2013b. "Archaeology of Religious Change: Introduction." *World Archaeology* 45 (1): 1–11.

Shaw, J. 2016a. "Religion, 'Nature' and Environmental Ethics in Ancient India: Archaeologies of Human:Non-Human Suffering and Well-being in early Buddhist and Hindu contexts." *World Archaeology*: 48 (4). 517-543. doi:10.1080/00438243.2016.1250671

Shaw, J. 2016b. "Archaeology, Climate-change and Environmental Ethics: Diachronic Perspectives on Human:Non-human:Environment Worldviews, Activism and Care." *World Archaeology* 48 (4): 449-465. doi:10.1080/00438243.2016.1326754

Sherratt, A. 1999. "Cash-crops Before Cash: Organic Consumables and Trade." In *The Prehistory of Food: Appetites for Change*, edited by C. Gosden and J. G. Hatler, 13–34. London: Routledge.

Sheridan, R. B. 1985. *Doctors and Slaves: A Medical and Demographic History of Slavery in the British West Indies, 1680–1834*. Cambridge: Cambridge University Press.

Sismondo, S. 2004. *An Introduction to Science and Technology Studies*. Malden, MA: Blackwell Pub.

Stopford, J. 1994. "Some Approaches to the Archaeology of Christian Pilgrimage." *World Archaeology* 26(1): 57-72. DOI: 10.1080/00438243.1994.9980261

Sykes, N. 2014. *Beastly Questions: Animal Answers to Archaeological Issues*. London: Bloomsbury Press.

Talbot, A. 2002. "Pilgrimage to Healing Shrines: The Evidence of Miracle Accounts." *Dumbarton Oaks Papers* 56: 153-173. doi:10.2307/1291860

Totelin, L.M. 2016. "Technologies of Knowledge: Pharmacology, Botany, and Medical Recipes." *Oxford Handbooks Online*. [10.1093/oxfordhb/9780199935390.013.94](https://doi.org/10.1093/oxfordhb/9780199935390.013.94)

Thomas, K. 1983. *Man and the Natural World: Changing Attitudes in England 1500–1800*, London: Penguin.

Thomas, R. 2017. "Towards a Zooarchaeology of Animal 'care'." In *Care in the Past: Archaeological and Interdisciplinary Perspectives*, edited by L. Powell, W. Southwell-Wright, and R. Gowland, 169-188. Oxford: Oxbow Books.

Tilley, L., and A. Schrenk. eds. 2017. *New Developments in the Bioarchaeology of Care: Further Case Studies and Expanded Theory*. New York: Springer International Publishing Switzerland.

Turner, J. 2004. *Spice: the history of a temptation*. New York: Vintage.

United Nations. 2015. *Transforming Our World – The 2030 Agenda for Sustainable Development: Resolution Adopted by the General Assembly on 25 September 2015*. Seventieth session, Agenda items 15 and 116.
http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

Unschuld, P.U. 2010. *Medicine in China: A History of Ideas*, Vol. 13. Oakland: University of California Press.

Van der Veen, M. 2003. "When Is Food a Luxury?" *World Archaeology* 34(3): 405-427.
<http://www.jstor.org/stable/3560194>

Van der Veen, M., and J. Morales, 2015. "The Roman and Islamic Spice Trade: New Archaeological Evidence." *Journal of Ethnopharmacology* 167: 54–63.

Walimbe, S. R. 1998. "Bio-Cultural Adaptations in Cranial Morphology Among the Early Farming Chalcolithic Populations of the Deccan Plateau." In *Contemporary Studies in Human Ecology: Human Factor, Resource Management and Development*, edited by M. K. Bhasin and S. L. Malik, 25–40. Delhi: Indian Society for Human Ecology.

Warinner, C., J.F.M. Rodrigues, R. Vyas, C. Trachsel, N. Shved, J. Grossmann, A. Radini, Y. Hancock, R.Y. Tito, S. Fiddyment, and C. Speller. 2014. "Pathogens and Host Immunity in the Ancient Human Oral Cavity." *Nature Genetics* 46(4): 336. [doi:10.1038/ng.2906](https://doi.org/10.1038/ng.2906)

Watts, N., N. W. Adger, S. Ayeb-Karlsson, Y. Bai, P. Byass, D. Campbell-Lendrum, T. Colbourn et al. 2017. "The Lancet Countdown: Tracking Progress on Health and Climate Change." *The Lancet* 389 (10074): 1151–64.

Wells, J. C. K., E. Pomeroy, S. R. Walimbe, B. M. Popkin, and C. Yajnik. 2016. "The Elevated Susceptibility to Diabetes in India: An Evolutionary Perspective." *Frontiers in Public Health* 4: article 145. [doi:10.3389/fpubh.2016.00145](https://doi.org/10.3389/fpubh.2016.00145).

Whitmee, S., A. Haines, C. Beyrer, F. Boltz, A. G. Capon, B. F. de Souza Dias, A. Ezeh et al. 2015. "Safeguarding Human Health in the Anthropocene Epoch: Report of the Rockefeller Foundation–Lancet Commission on Planetary Health." *The Lancet* 386: 1973–2028.

WHO 1993. Guidelines on Conservation of Medicinal Plants. IUCN, Gland. Switzerland.

Wilkie, L. A. 1996. "Medicinal Teas and Patent Medicines: African-American Women's Consumer Choices and Ethnomedical Traditions at a Louisiana Plantation." *Southeastern Archaeology* 15 (2): 119–131.

Williams, K. 2007. "Historical and Emerging Themes in Parenteral Manufacturing Contamination Control." In *Endotoxins: Pyrogens, LAL Testing and Depyrogenation*, edited by K. Williams, 1-22. CRS Press.

Wu, F., H. Li, L. Jin, L. Xiaoyu, Y. Ma, J. You, S. Li, and Y. Xu. 2013. "Deer Antler Base as a Traditional Chinese Medicine: A Review of its Traditional Uses, Chemistry and Pharmacology." *Journal of Ethnopharmacology* 145(2): 403-415. <https://doi.org/10.1016/j.jep.2012.12.008>.

Wujastyk, D. 2004. "Medicine and Dharma." *Journal of Indian Philosophy* 32 (5/6): 831-42.

Xu Q, R. Bauer, B.M.Hendry, T.P. Fan, Z. Zhao, P. Duez, M.S. Simmonds, C.M. Witt, A. Lu, N. Robinson, D.A. Guo, and P.J. Hylands. 2013. "The Quest for Modernisation of Traditional Chinese Medicine." *BMC Complementary and Alternative Medicine* 13(1):132.

Zimmermann, F. 1980. "Ṛtu-satmya: The Seasonal Cycle and the Principle of Appropriateness." *Social Science and Medicine* 14B: 94-106.

Zimmermann, F. 2004. "'May Godly Clouds Rain For You!' Metaphors of Well-being in Sanskrit." In *Du corps humain, au carrefour de plusieurs savoirs en Inde: Mélanges offerts à Arion Roşu par ses collègues et ses amis à l'occasion de son 80ème anniversaire*, edited by E. Ciurtin, 371-84. *Studia Asiatica*, 4-5. Bucharest: Centre d'Histoire des Religions de l'Université de Bucarest/Paris: De Boccard.

Zysk, K. G. 1986. "The Evolution of Anatomical Knowledge in Ancient India, with Special Reference to Cross-cultural Influences." *Journal of the American Oriental Society* 106 (4): 687-705.

Zysk, K. G. 1991. *Asceticism and Healing in Ancient India: Medicine in the Buddhist Monastery*. New Delhi: Motilal Banarsidass.

Zumbroich, T.J. 2012. "From mouth fresheners to erotic perfumes: the evolving socio-cultural significant of nutmeg, mace and cloves in South Asia." *eJournal of Indian Medicine* 5: 37-97.