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Disease in Big History
by *Philip Day*

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Cover picture: *The Triumph of Death* is a fresco in the Regional Gallery of Palazzo Abatellis in Palermo, Italy. The artist of the work, which is dated around 1446, is unknown.

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Disease and Big History: A Dark Side of Interaction

By Philip Day

Abstract

Epidemic and pandemic disease are a major contemporary world hazard, and have also acted as a major driving force in human history. As such, disease constitutes a 'dark side' of interaction, which can otherwise act as a creative force across many domains in Big History. This paper explores causal factors and patterns in the emergence of communicable diseases throughout the last ten thousand years to the present day, and how they have shaped human affairs. We consider the Columbian Exchange as the greatest example of disease asymmetry and perhaps the most significant disease exchange event in human history, leading to Amerindian holocaust and a 'windfall' for Europe that facilitated her rise to global dominance by 1900. We seek ultimate causation in the distribution and internal geographies of the continents. The Columbian disease asymmetry forces us to ask hard questions about disease emergence, which are not entirely resolved. We propose that livestock act as crucial intermediaries between special types of wildlife that form sympatric and/or gregarious networks conducive to zoonotic transfer (bats, birds and rodents), and the dense networks of human agricultural, urban and industrial societies. Recurrent factors in disease emergence include human and livestock density and connectivity, and ecological disruption. Each of these crossed new thresholds in modern times, events which should urge caution, and which demand prudent investment in programs for the prevention, monitoring, response to and eradication of disease.

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Introduction

Disease as a Special Case of Interaction in Big History

Interaction, exchange and horizontal information transfer constitute a recurrent theme in Big History, spurring innovation and the advance of complexity across multiple thresholds (Christian, 2004). Nuclear fusion acting at high pressure inside stars produces large atoms ultimately from simple hydrogen; life originated from the reactions among different varieties of carbon-chain molecules trapped in microscopic cellular structures (Martin and Russell 2003 and 2007; Lane 2009); subsequent biological evolution appears to have been accelerated by sexual recombination, symbiosis and horizontal gene transfer, including by viral agents (Margulis 1970; Lane 2009; Ryan 2009 and 2016; Villarreal 2004 and 2008; Claverie 2006; Forterre 2013); genomic restructuring permits more rapid exploration of evolutionary space by recombining whole protein domains in novel ways (Shapiro 2011); various forms of exchange, within and among societies, have enabled collective learning and accelerated development across multiple phases of human history, from prehistory to modern industrial and technology complexes (McNeill, W. H. 1963; McNeill, W. H. and McNeill, J. R. 2003; Christian 2004); etc.

Disease is a dark side of interaction among human societies and among animal species, including between humans and animals; it has played a major, under-reported role in human history, shaping the fates of societies large and small (McNeill, 1976). Modern science has recorded an impressive list of achievements of reducing disease footprints and virulence, in some cases even eradication.[1] Nevertheless, disease continues to exact an onerous burden on the health and resources of under-developed tropical countries today, certain historical diseases are making alarming comebacks, and novel outbreaks are numerous if, so far, largely contained (Oldstone 2010, Quammen 2012). Global pandemic is identified as one of the major hazards facing humanity today and in the foreseeable future (Smil 2008). This paper surveys the impact of disease in human history, in particular the Columbian Exchange, and seeks recurring patterns and causes which influenced the course of world history, and which might illuminate our current relationships with disease.

Interactions are physical events which take place where conditions permit; where such conditions vary, patterns of interaction are structured through time and space. Therefore, topography matters. Interaction among and within human societies is particularly influenced by geography, which provides opportunities and constraints for population densities, travel and transport at all scales. Therefore if we are correct to identify interaction as a driving source of human social development in general and of disease in particular, our explanations of macro trends must consider geography; we identify the distribution and geographies of the continents as a significant factor behind differential disease burdens among societies, and as an ultimate arbitrator of the fates of societies at the largest scales.

Infectious disease is a consequence of a particularly intimate form of

1 *'Virulence' refers both to the infectiousness of the pathogen, and the degree of damage it causes to the host.*

microparasitic predation, in that the parasite lives inside the host organism, drawing on the host's resources of energy and matter to varying extents, sometimes to the point of killing the host. *Communicable* disease is caused by a pathogen which transmits from host to host, either among conspecifics or across one or more species barrier. The parasite might be a free-living agent within the hosts' tissues (bacteria, single-cell eukaryotes, worms), or inside hosts' cells (viruses, even some bacteria such as *Rickettsia* that causes typhus), or even genomes (retroviruses).[2] Various scientists are beginning to suspect the last category is an important source of genetic innovation in the history of life, particularly associated with speciation events, including (perhaps especially so) in the human lineage (Ryan 2009). Although fascinating, this topic is beyond our scope.

So, at one level, we see interaction (parasitism) between host and pathogen, at another level interaction among individuals as the disease organism transfers from host to host, and also among species when *spillover* events occur. This paper is particularly concerned with spillover events from animals to humans, from which might *emerge* [3]'zoonotic' diseases, and with diseases exchanged among human societies.

Many of the arguments and trends discussed here apply also to disease and pest burdens among animals and even plants (Daszak et al. 2000; Gibbs et al. 2008); although ecologically and economically important, these topics are beyond our scope.[4]

<ins>Mechanisms of Infection, Transmission and Emergence</ins>

We are surrounded by enormous numbers of microbes - in the air, on surfaces, our skin, eyes, mouths, guts, etc., but do not commonly suffer infection thanks to our body's natural defences (skin, blood coagulation to close wounds, adenoids, tonsils, stomach acid, symbiotic microbiota, etc., and of course our adaptive immune system). Ingress usually requires some breach, such as consuming contaminated food or water, or a deep wound, but such a successful infection would typically lack a transmission mechanism to another host.[5]

Therefore, the majority of human communicable diseases emerged after zoonotic spillover (Wolfe et al. 2007; **Table 1; Appendix A)**, because they had to adjust a lifecycle already adapted to animal (typically mammalian, or bird) infection and transmission, rather than invent it from scratch. Even then, it is rare for a spillover event to lead to emergence in the new species because of the complex adaptations required and interim loss of fitness (Parrish et al. 2008; Geoghan et al. 2016); Wolfe et al. (2007) delineate the intermediary stages in the process.

Some pathogens are of human origin, such as rhinoviruses of the common cold or polioviruses that cause polio, both of whose ancestors were benign enteroviruses in the gut; tuberculosis originated from commensal (perhaps symbiotic) bacteria of the lungs (Jiang et al. 2007; Adler 2013; Brites and Gagneux 2015; **Appendix A**).

Transmission pathways include aerosols (droplets in the breath), touching, sexual contact, mucus contact, one or more intermediate 'vector' species, especially insects, sometimes a free-living stage for bacteria or eukaryotes, permitting use of the faecal-oral route, ingestion of prey or partially-eaten food, etc. Diseases that transmit directly between conspecifics require a host population of sufficient size and density to maintain a supply of inexperienced hosts for a chains of infection to persist. Diseases which rely on vectors depend on appropriate environmental conditions for the vector and/or reservoir populations. Diseases which spillover from one species to another correlate with areas of wildlife species diversity, particularly avian and mammalian (Jones et al 2008; Dunn et al. 2010). The importance of genetic distance is unclear; mammals generally and primates

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2 Another, bizarre and extremely rare, category is transmissible cancerous cells, including Canine Transmissible Venereal Tumor, a sexually-transmitted cancer which managed to survive in dogs other than its original self (infectious cancers are typically triggered by some transmissible agent, such as a virus, but the cancers themselves do not usually travel between hosts) https://en.wikipedia.org/wiki/Canine_transmissible_venereal_tumor. It has long been debated whether viruses constitute living organisms; Patrick Forterre proposed the concepts of virion and virocell to resolved the debate (Forterre, 2011 and 2013): virions are the entities which transfer between cells; within a cell some viruses setup a cell-like structure, which constitutes less ambiguously a living organism. The inert extra-cellular virion is analogous to seeds or spores of plants. Prions constitute a strange category of infectious agent: deformed proteins which catalyse the same deformity in other proteins they make physical contact with e.g. scrapie in sheep, BSE in cattle, CJD in humans, etc.

3 The concepts of spillover and emergence are broken down by Wolfe et al. into five stages of increasing capacity of and dependency on transmission among humans (Wolfe et al. 2007)

4 Also out of scope are consideration of the biomolecular mechanisms of infection and immunity, the important modern phenomenon of bacterial resistance to antibiotics , and non-communicable human disease.

5 Legionnaire's disease was first recognised emerging from a bacterium in the cooling tower of an air-conditioning system in a hotel in the U.S., 1976, killing 35 people (Quammen 2012). It grows in standing freshwater, with amoebae as a reservoir, infects tens of thousands people per year worldwide, but does not transmit from human to human (Bartram et al. 2007).

especially are over-represented among reservoirs of human diseases (Wolfe et al. 2007; Davies and Pedersen 2008; Han et al. 2016), but more-distant rodents, bats and birds are well represented too (Parrish et al. 2008).

In general, both higher population densities and environments in which conditions *outside* the host more closely resemble those *inside* the host (i.e., warm and wet) favour disease transmission. Hence, humid, typically low-altitude tropical regions contain more pathogens than temperate, cold, high-altitude or dry regions (McNeill, W. H. 1976; Jones et al. 2008).[6]

Spillover and emergence events are often associated with ecological and/or societal disruption or transformation, which might present new opportunities of proximity, connectivity or barrier removal, both in ancient and modern times (McNeill, W. H. 1976; Jones et al. 2008; Keim and Wagner 2009; Oldstone 2010; Engering et al. 2013; Morand et al. 2014). Recent analyses have explored properties of networks as predictors of various aspects of disease hosting and transmission (Anderson and Sukhdeo 2011; Gomez et al. 2013; Luis et al. 2015).

Many authors observe that our understanding both of the histories of specific infectious diseases and of general patterns of transmission are limited. At the same time, rapid advances are being made in terms of accumulating and analysing data, including new analytical techniques and theoretical frameworks (Harper and Armelagos 2013; Morand 2015; Han et al. 2015; Geoghan et al. 2016). The field is therefore exciting to study; some of the hypotheses put forward here must remain tentative and are likely to be revised as our understanding evolves.

Evolutionary Strategies of Pathogens

Virulent pathogens and their hosts are locked in an arms race for control of the hosts' resources, but the pathogen faces a trade-off: the more it succeeds, the more copies of itself it can make that might achieve transmission to another host, but if it is *too successful* it might immobilise or kill the host. So highly virulent infection transmissible among conspecifics either burns out rapidly, or host and pathogen co-evolve a balanced level of virulence, or long latency. HIV has been observed evolving a slower rate of progression since its discovery in 1980; when syphilis arrived in Europe in the 1490s it killed in months, within a few decades it took years and today infected persons can survive up to 30 years untreated (Knell 2004).[7]

It is a puzzle therefore why do lethal communicable diseases exist? Large, dense, naïve populations permit high virulence to endure for longer, but surely this merely postpones the inevitable? Ryan (2009) emphasises the role of inter-species spillover: selection is acting on the *symbiotic union* of reservoir host *plus* pathogen to maintain powerful biological weapons, which serve a role in inter-species conflict, perhaps clearing rivals from their ecological space. More mundanely, it might be that asymptomatic zoonotics do not gather so much attention; those which cause virulent spillover might be anomalies which make the headlines (Quammen 2012).

Ryan's suggestion is nevertheless useful as a *metaphor* for certain disease encounters, for example the displacement of native red squirrels in the UK by imported greys and the squirrelpox viruses they harbour (Sainsbury 2000).[8] It has been argued recently that disease played a role in the displacement of *Homo neanderthalensis* by *Homo sapiens* in Europe and Asia c. 40-30 kya (Houldcroft and Underdown 2016), and we will observe such trends in the historical era below. These processes are analogous to that of the Penicillin mould in a petri dish, whose antibiotics, acting as an advance wave, clear bacteria from the adjacent space that the mould will grow into, as famously observed by Alexander Fleming in 1928.

Human Disease in World History

If disease might have played a role in the expansion of our species at the expense of hominid rivals, it certainly played a major role in our subsequent history. Since records begin, human societies have been assisted in the processes of displacing, conquering or resisting rivals where a 'disease gradient' has existed between groups, most spectacularly in the case of the Columbian Exchange. Some

6 *Considering this observation in light of Vermeij's (2004; see above) insight about speciation and radiation centring in energy-dense tropical regions, it is intriguing to speculate whether disease plays some role in both the acceleration of innovation through horizontal gene transfer, and in colonisation of less disease-experienced areas by tropical species carrying disease. Tropical conditions are conducive to disease; disease is conducive to speciation; disease gradients facilitate colonisation and displacement. Did hominid lineages evolving in Africa repeatedly emigrate and displace Eurasian rivals because of disease?*

7 *This is true in some regions such as Africa but not in Europe where treatment is more available; eventual untreated fatality rates in all regions remain close to 100% (Cairns 2014).*

8 *See also https://en.wikipedia.org/wiki/Squirrel_parapoxvirus for a concise summary.*

of these asymmetries correlate with obvious environmental conditions such as population densities or temperate vs tropical climate, but the Columbian Exchange constitutes a puzzle because the asymmetry applied across multiple diverse human environments; again, we will identify the role of inter-species transfer in our solution.

Several lines of evidence help us reconstruct histories of human pathogens and their diseases. These include: observations of which microbes currently infect which animals and with what level of virulence; genomic sequencing of pathogens, which helps reconstruct phylogenetic trees, infer reservoir populations and estimate dates of branching events; skeletal and dental evidence from ancient graves, and microscopic study and genomic sequencing of pathogens found in them; genomic sequencing of humans that can date the appearance of genetic resistance, indicating an evolved response to an emergence event; various techniques to reconstruct demographic data which can indicate population crashes that might be linked to epidemics; and written records since the dawn of literate civilization. These evidence sets in combination are particularly powerful, e.g. abstract phylogenetic relationship trees can be pinned to specific points in time and space by molecular clocks and archaeological and textual evidence. One note of caution is that molecular biologists do not always agree on the interpretation of genomic analysis, and some datings have undergone significant revision (Wertheim et al. 2011; Wertheim et al. 2013; Rasmussen et al. 2015).

<u>Communicable Diseases of Humanity</u>

Table 1 shows selected major human communicable diseases by human/animal origin and estimated date of emergence. It includes the diseases which have the highest death tolls and largest impacts on the course of human history. Further information, including discussion of uncertainty and references, can be found in Appendix A.

Estimated emergence date at or before		Completely Unknown	1my	100kya	10kya	5kya	2.5kya	1kya	100ya	0 ya
Human Origin		Rhinovirus strains of common cold	Ancestral Tuberculosis; Yaws?		Tuberculosis major lineage split c. 30 - 20 kya	Virulent Tuberculosis: Syphilis (New World)	Typhoid; Polio		Tuberculosis expansion; Epidemic Polio; Syphilis in the Old World	
Animal Origin	Human to Human transmission	Coronavirus strains of common cold				Black Death (pneumonic strain)	Small pox; Influenza	Black Death pandemics; Measles	HMPV (minor strain of Common Cold)	HIV / AIDS; Ebola; SARS
Animal Origin	Vector / environment transmission			Ancestral Malaria?	Virulent Malaria c. 10kya		Cholera in India	Black Death pandemics; Typhus; Yellow Fever	Cholera globally	Zika; Nipah

Table 1: selected major human communicable diseases by origin type (human/animal) and estimated date of emergence.

We note that most diseases listed in **Table 1** have emerged since 10kya, the dawn of the Holocene and the time of the transition to agriculture, and later urban civilization. More ancient diseases such as tuberculosis (TB), yaws (the probable ancestor of syphilis as well as a longstanding disease in its own right) and malaria have origins deep in prehistory but which, according to evidence from both human and pathogen genomes, increased their virulence and diversity since c.10kya. The number of diseases whose origins are identified as human and/or dated pre-Neolithic has gradually increased with better genomic evidence, influencing a subtle rethink of the nature of the threshold in human disease experience associated with agriculture and domestication (Harper and Armelagos 2013; Houldcroft and Underdown 2016). TB for example was formerly thought to be zoonotic; it turns out cattle acquired it from humans, perhaps via an intermediary (Garnier et al. 2003; Harper and Armelagos 2013). But the importance of agriculture as a threshold in pathogen richness and virulence will likely endure.

Geographical origins and reservoir species of zoonotics are provided in

Appendix A: all but syphilis originated in the Old World; where known, most pathogens descended from ancestors whose original hosts were livestock, primates, rodents, bats, birds, or from humans' own microbial commensals and symbionts.[9]

Primates are humans' closest animal relatives and have been sympatric with humans for very long durations (i.e. their ranges overlap), in tropical regions where vectors abound; relatedness and multiple spillover events increase the likelihood of emergence (Davies and Pedersen 2008; cf. Daszak et al. 2012).

Livestock are by definition *synanthropic* (live in proximity to humans); they acted as intermediaries in at least two major communicable diseases: smallpox (from gerbils to camels (camelpox) to humans), and measles (bats to cattle (rinderpest) to humans). As pack animals are often kept in dense pens and then eaten by humans, they presented opportunities for aerosol and faecal-oral pathways to emerge. They are also suspected as acting as intermediaries or amplifiers in modern viral spillover events, e.g. influenza (pigs, poultry), SARS (civet[10]), MERS (camels), Hendra (horses), Nipah (pigs), possibly Ebola (pigs) too.

The recent (1997) case of Nipah virus emergence in Malaysia allowed us to observe the dynamics of wildlife-domesticate-human interaction in detail (Pulliam et al. 2012; Engering et al. 2013). Pigs were kept close to mango trees, a food source for flying foxes, and became infected with a henipavirus from urine or saliva that contaminated fruit half-eaten by the bats. The spillover caused epizootics (epidemic among animals) that quickly went extinct, but descendants of the survivors provided a fresh supply of immunologically naive individuals, with a high rate of population turnover, which permitted the pathogen to remain enzootic on re-introduction, and perhaps develop respiratory transmission among pigs. Pigs therefore became a reservoir from which the virus could jump to humans by aerosol transmission, thanks to proximity on farms or in slaughterhouses. Movement of pigs between farms, to slaughterhouses and overseas subsequently spread the virus regionally, and eventually as far as India and Bangladesh. We note the importance of pigs as a conduit and amplifier: humans typically eat washed, cooked food, discard blemished fruit, etc., and do not usually directly contact wildlife, so the virus

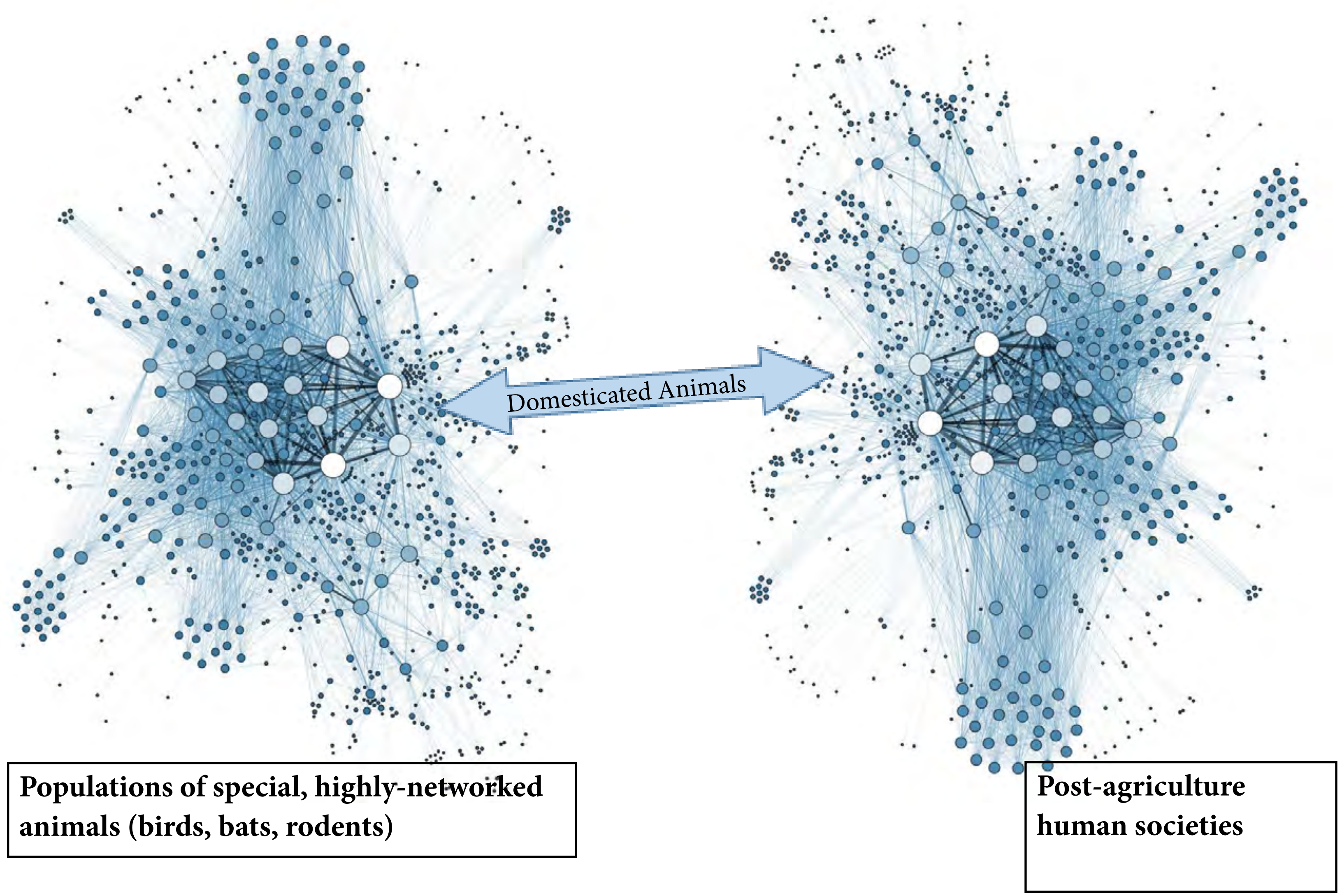

Figure 1: schematic illustration of the argument that domesticated animals acted as bridges between densely connected networks separate from each other: human societies and populations of special types of animals. If not for domesticates' intimate contacts with both networks, they might likely remain too lightly connected for epidemics to emerge. [Philip Day], 2017.

9 Chagas disease, of New World origin, is included in the Wolfe et al. (2007) original from which this table has been adapted; it is vector-dependent, most likely of wildlife origin, has not caused epidemic nor escaped the Americas until recent decades; its pathogen is a distant relative of those which cause sleeping sickness in Africa (Wolfe et al. 2007).

10 The civet is a wild animal that was kept in cramped conditions in food markets at the time of this outbreak; see SARS example below.

needed pigs to bridge the gap physically, and to develop mammal-mammal aerosol transmission. There are no known cases of humans catching the virus from mango fruit, and cases of direct bat-human transmission are rare.

Birds, bats and rodents all share the property of having large ranges that link to form larger, perhaps global networks of *sympatric* species (i.e. species whose ranges overlap); many also exhibit *gregariousness* (dense colonies); these features are shown to predict pathogen richness and/or zoonotic potential (Davies and Pedersen 2008; Luis et al. 2015). It might be relevant therefore to consider livestock as pivots between the great communication networks of special types of animals that live sympatrically and gregariously, i.e. rodents, bats and birds, and those of humans. This argument is illustrated in Fig. 1.

Han et al. (2016) report their very recent discovery that carnivores are major sources of modern zoonotics; approximately 49% of all carnivore species harbour at least one zoonotic pathogen, perhaps accumulated from their prey species. It is noteworthy that carnivores do not register at all in the roster of hosts of historical diseases, even though they were greater in headcount, species count and proximity to humans in the past. We hypothesise that because humans maintained a distance between carnivores and livestock – the definition of animal husbandry – as well as from themselves, there was not enough *persistent* contact for any transmission event to proceed to emergence. In contrast, proximity with birds, bats and rodents is relatively unavoidable.

The rise in disease burdens after c. 10kya occupies much of the rest of this paper. We will observe that new opportunities for spillover and emergence events associated with ancient agriculture and civilization share some commonalities with those of modern times, namely: ecosystem disruption, proximity to animals, and human density and connectivity.

Agriculture and Civilization

The environmental changes associated with emergence of agriculture and civilization presented many novel opportunities for pathogens to spillover and emerge as human diseases, and saw perhaps the first instances of lethal aerosol-borne epidemic. Changes included larger, more dense populations, proximity to livestock and rodents feeding on wastes, proximity to wastes, contaminated drinking water, standing water, trade networks, military disruption, etc. Fossil records reveal increasing disease burdens as one aspect of a general decline in human health and lifespan associated with these new lifestyles, in all parts of the world (Diamond 1997; Martin and Goodman 2002; Harari 2013).[11] Written records are patchy and present challenges of diagnosis for multiple reasons, but make clear that ancient peoples were familiar with the phenomenon of disease, including lethal epidemics, since the earliest times (McNeill, W. H. 1976).[12] Examples include Mesopotamian, Egyptian and Chinese royal court records, the *Epic of Gilgamesh* (one of the earliest works of literature), and the Bible.

Impact on the Course of Human History

Disease gradients emerged between societies and environments with different disease burdens, which at times facilitated and at times impeded the expansion of agriculture, animal husbandry and civilization. Asymmetric outbreaks could determine the fates of wars or even whole empires, or lead to displacement of entire ethnic groups by rivals. Major examples include the Plague of Athens (probably typhoid fever,[13] 430 B.C.E.), the Antonine Plagues (smallpox, Rome, 160s C.E.) and coincident plague in Han China, which point to the 'Silk Road' network as playing a major role in transmission for the first time. Black Death shrank the Byzantine Empire c. 540s C.E. and broke up the great Mongol Empires c. 1350s C.E., which had protected a new peak in Silk Road connectivity. Even the fates of great religions could be shaped by pandemic; nursing behaviours during the Antonine Plagues

11 *Repetitive manual labour especially bending, and diets of lower nutrient and higher calorie content, stunted and warped skeletons and degraded dental quality.*

12 *Contemporary observers were not trained in the modern scientific method; ancient written records are subject to heavy rate of loss; terminologies were not consistent across time or space; diseases progress differently from patient to patient; different diseases can have similar or overlapping symptoms that require a trained eye to differentiate; diseases evolve. Syphilis for example progressed very differently on first exposure in 16th-century Europe, witnessed by disfiguring ulcers and killing rapidly, than it did in later centuries or did in pre-Columbian America, when the host survived long enough for bone lesions to appear. Symptoms have also been mistaken for yaws or leprosy. Such tangled evidence helps explain why consensus has begun to consolidate only in recent years that syphilis is of New World origin and entered the Old World via Europe with Christopher Columbus in 1493 (Knell 2004, Harper et al. 2011, Cruse 2014).*

13 *Hypotheses include plague, smallpox, measles, typhus, even haemorrhagic fevers such as Ebola or Marburg virus; the latest most confident assertion cites typhoid fever (Papagrigorakis 2006)*

attracted Romans to Christianity (McNeill, W.H. 1976), while the Justinian Plagues amid famine and wider disruption associated with a 539 C.E. volcanic created space for the rise of Islam (McNeill, W.H. 1976; Keys 2001; Sigl et al. 2015).[14]

After 1500 C.E.

By 1500 C.E., African and Eurasian societies had experienced many millennia of farming, animal husbandry and urban living, and at least two millennia of strong connectivity associated with trade networks linking all major centres of civilization and population density. These societies therefore hosted a formidable arsenal of pathogenic symbionts, while marginal or uncontacted societies did not, which means the latter were compelled to eventual demographic disaster. Suffering the worst losses where people native to the Americas, the far south of Africa, Australia, New Zealand and lesser islands of Oceania, and Siberia (subject to Russian overland expansion).[15]

On the other hand, tropical regions were, or soon became, home also to an array of pathogens exotic and deadly to Europeans. These two general trends help explain much of the pattern of white European colonisation from c. 1500 to 1900 (McNeill, W. H. 1976; Abernethy 2000).

It remains to be explained why the Americas, Australia, etc., did not *also* present any significant disease hazard for European arrivals. We will consider this asymmetry below as part of our discussion of the Columbian Exchange and its monumental consequences for subsequent world history.

The Columbian Exchange

Overview

Interaction and exchange have served as a – perhaps *the* – critical driver of innovation and complexity throughout human history; the 'Columbian Exchange' is perhaps the largest and most significant set of exchanges that can be classed as a single 'episode', even if many of the specific transfers took centuries to unfold in full (McNeill 1963; Crosby 1972, McNeill, W.H. and McNeill, J.R. 2003; Christian 2004). Benefits were many and widely shared, particularly the transfer of germ lines of various strains of potato,[16] tomato, peanut, chilli, maize, cassava, etc., permitting significant population rises in Africa, Europe and Asia (Mann 2011; Flynn et al. 1997). New World metals, especially Andean silver, would play an important role in lubricating world trade (Flynn and Giraldez 1995; Flynn and Giraldez, 1997).[17] Negative aspects included pandemic, local demographic and economic collapse, expansion of slave and narcotic trades, pest transfer, environmental degradation, etc. Net gains accrued disproportionately to those who controlled the shipping, both in the Atlantic and eventually (from c. 1700) globally: Europeans.

From Encounter to Windfall

By quickly crushing Amerindian polities, unleashing pandemics and exploiting the disempowered survivors, Europe gained a 'windfall' of land, resources and trade routes that played no small part in its rise in technical, economic and political power, and eclipse of the rest of the world over the following four centuries to 1900 (Pomeranz 2000). European civilization was able to spread onto and command the resources of territories much larger than its home region, enormously expanding its footprint while relieving population pressure at home. In a positive feedback effect, Europe's accelerating development further increased her capacity to exploit her American possessions.

Disease asymmetry is well attested as the most important cause; we point to

14 See also Appendix A for a suggestion by Babkin and Babkina (2015) that volcanic activity (the Santorini event) was behind the ecological disruption leading to the emergence of smallpox c. 4kya.

15 Many of the arguments presented with respect to the Americas throughout this paper apply also to these smaller peripheral regions.

16 Potatoes are credited by William H. McNeill as minimizing the damage to agriculture done by the movement of armies during the great wars of the mid-18th Century and Napoleonic period, because of the difficulty of quickly harvesting or destroying them (in contrast to, say, wheat). Civilian populations suffered much more greatly during the Thirty Years War of the 17th century, before the potato had arrived and spread (McNeill, W. H. 1999). Elsewhere, the sweet potato variant facilitated the post-1700 boom in the population of Qing China, and similarly even in the remote New Guinean highlands, which would not be incorporated into permanent contact with the rest of the world until the 1930s (Flynn and Giraldez 2008).

17 Indian opium was another 'windfall' commodity which enabled Europeans (British in this case, from c. 1760s to 1900) to balance their trade with China and finance their colonies. The problem was European manufacturers were too unsophisticated to generate Asian demand until c. 1830 (Darwin 2007); in earlier times Portugal paid their way by running a naval protection racket, based on the cartaze.

domesticated livestock as the main reason for the disease asymmetry. A more general power imbalance is also identified, and is more striking when contrasted to the situation just 500 years earlier. We identify disparities in size and connectivity of the Old and New Worlds as causes of both power and disease asymmetries, and the random arrangements and geographies of the continents as ultimate causes.

Amerindian Civilizations in Comparison

The scale of the European achievement is all the more striking when we consider the size and magnificence of Amerindian civilizations, and the relative weakness of Europe just a few centuries earlier, c. 1000 C.E. In each of the big three, especially the Aztec realm, there were large cities (more than 200k inhabitants in Tenochtitlan, as many as the largest of Europe), complex social hierarchies, long-distance trade, division of labour, sophisticated markets, public education (Aztecs), forms of writing (Aztecs, Maya) or other information storage (Incan Quipu), well-organised empires that exercised power over very long distances (Inca), and large armies (Aztecs, Incas c. 10s of thousands) (Mann 2005).

European military technology by 1500 C.E. was superior to that of Amerindian societies, especially cavalry and steel, and the shock factor of firearms, but counterbalanced by their limited ability to project power over large distances by sea at this time, and by Amerindians' numerical dominance. Columbus' tiny caravels carried only a few hundred persons in total; Pizarro's tiny band surrounded by the vast Incan armies were fearful and despondent before he executed his masterstroke at Cajamarca from a position of desperation (Prescott 1847).

Disease, Holocaust and Conquest

The central and critical roles of disease in the conquest of the great Amerindian empires are well attested, including loss of manpower, disruption to leadership, disorganisation, shock and collapse in morale (McNeill, W. H. 1963 and 1976; Crosby 1972; Diamond 1997; Mann 2005) and we need not go into details here. We note that smallpox and measles lead the charge of several major disease invasions, and that pre-Columbian population slumped from c. 50-100m to c.2m by 1600. Epidemic die-off continued throughout the ensuing centuries, often unwittingly and progressing ahead of the wave of advance under its own dynamics like Fleming's penicillin, but sometimes deliberately,[18] and is still ongoing in the Amazon basin today.[19]

In contrast, no significant demographic blow was suffered either by European arrivals,[20] or by the population of Europe itself. Recent scholarship (Harper et al. 2011) has identified syphilis as the only Amerindian disease to make it back to Europe (and beyond);[21] we will return to reasons for the asymmetry below.

Holocaust, Land and Migration

Despite large areas off limits thanks to malaria and yellow fever, enormous emptied lands offered an outlet for population pressure, realised fully only after trans-oceanic travel became cheaper and the recently-independent USA opened her doors to immigrants of all countries in the early 19th century. Although this did not prevent the late-18th century demographic crisis associated with the French Revolution (and its less-dramatic echoes in other states) and ensuing continental warfare, or subsequent lesser revolutions in 1820, 1830 and 1848, it arguably diverted a more catastrophic crisis such as those which engulfed Europe in the early 14th century or in the early-mid-16th century, or such as the fifteen years of intense warfare that devastated China c. 1850-64, known as the Taiping Rebellion

18 *Weaponised smallpox was delivered in contaminated gift blankets as early as 1763, by British officers in North America (Oldstone 2010).*

19 *See for example, https://www.theguardian.com/world/2014/aug/01/amazon-tribe-makes-first-contact-with-outside-world.*

20 *In a postscript to the familiar story, the disease gradient reversed for Europeans in the Caribbean islands and adjacent lands after the 1640s, when mosquito-borne tropical African diseases become established (malaria and yellow fever). Initially causing pandemic and later settling in as epidemics to which childhood survivors gained lifelong resistance or immunity, they did not dislodge existing European populations but effectively precluded fresh arrivals. This was a major factor in the expansion of black African slave labour, the failure of Great Britain to capture any of the Spanish imperial jewels, and settled many of the later independence conflicts in favour of the rebels. These regions became inhabitable for newly-arrived Europeans once more only after c. 1900, thanks to advances in medical science (McNeill 2010).*

21 *This is not to say the impact of syphilis in Europe was negligible; it disrupted elite society; the early demise of Lenin (d. 1924), for example, has long been suspected of being caused by syphilis http://www.ncbi.nlm.nih.gov/pubmed/21970074, although this position has opposition http://blog.oup.com/2015/01/death-vladimir-lenin-world-communist-revolution/. Lenin was turning against Stalin in his later years, and if Lenin's health had not declined rapidly during 1922-24, Stalin might never have come to power.*

(Goldstone 1988 and 1991; Fischer 1996; Turchin 2009). The climax of European economic and political world supremacy by 1900 might not have been possible without such a long period of relative internal stability, since c. 1815.

In fact, some historians of the industrial revolution attribute its advent in 18th century Britain to high wages (Allen 2011), which, although they do not seem to consider this, would surely not have been possible without the emigration of labour to Americas (and Ireland) before and after 1700. A proper exploration of this controversial question is beyond our scope, but worth noting.

Other Factors

Finally we should note that the polyethnic and sharply hierarchical nature of Amerindian Empires facilitated their takeover. Both Cortes and Pizarro could thus attract significant corps of native allies; Cortes' conquest of the Aztecs is probably best considered as a mass rebellion which he managed to foment and take leadership of. Well-organised Incan resistance movements eventually emerged, but too just late; Incas regrouped and narrowly failed to achieve their own *Reconquista* of Cusco in 1536, before Spanish reinforcements arrived.

We have surveyed the disease and power imbalances, and other features of the Amerindian states, which facilitated European conquest of the Americas. It remains to be explained how the imbalances arose.

Pre-Columbian Asymmetry

Old World Connectivity and European Development

The growth of Europe after 1500 C.E. understandably attracts far more learned attention, but before those economic wonders were achieved, Europe's rate of development c. 1000-1500 C.E. was already remarkable in the context of human history. Proper discussion is beyond the bounds of this paper, but we might point to a few high-level factors. Europe underwent an agricultural, technological, population and economic boom beginning around 1000 AD, including rapid growth of towns and cities for the first time since the collapse of the Roman Empire.

Such dramatic advancements were built on a rich inheritance both of local origin and more widely from many millennia of Afro-Eurasian innovation, imported (or re-imported) mostly from Muslim neighbours. European agricultural techniques, crops, livestock, tools, weaponry, etc. were almost entirely of Asian origin. The Muslim world was large and well connected both internally and externally at this time, both over land and sea, and remained so even after disruptive Turkish and Mongol conquests of the 12th and 13th Centuries. Thus Arabian geometry and navigation, Indian mathematics and later Chinese technologies such as gunpowder and the compass gradually percolated into Europe in the period 1000-1500 C.E. The Portuguese caravel, the workhorse of the Age of Discovery, used key planking techniques learned from North African Arabs, ultimately of Greco-Roman origin (Sleeswyk 1998). The sugar crop, plantation production system and international slave trades comprised a package that became the engine of the European New World colonial economy during its 18th century height; all had their origins in the Arab eastern Mediterranean pre-1400, and gradually migrated under first Italian then Spanish and Portuguese direction to the Western Mediterranean, Atlantic islands and the Americas (Davis 2006).

In fact, ancient Old World civilizations had been stimulated by interactions with each other since earliest times, thanks to camelids, equines, sails, monsoon winds, traversable grasslands, navigable rivers connecting diverse hinterlands, etc. (McNeill W. H. 1963; McNeill, W.H. and McNeill, J.R. 2003; Bernstein 2008; Broodbank 2013). An east-west principal axis entailed consistent climate over long-distances, facilitating the spread of agricultural practices and the movement of peoples, technologies, etc. (Diamond 1997). The European achievement by 1500 C.E. was therefore very much a product of the Afro-Eurasian 'human web' of interactions (McNeill, W. H. and McNeill, J. R., 2003). Such bountiful endowments of the human past were not accessible to Amerindian populations, who innovated independently of the Old World.[22]

22 One significant exception is archery, which appears to have entered northern America from Asia in four waves, at c.12, 4.5, 2.4 and 1.3kya. most of these technologies were more relevant for hunting than for inter-human conflict, except for the 1.3kya event, which saw the spread of the 'Asian War Complex' including the composite bow and associated armour. This increased the rate and nature of conflict and initiated reorganisation of societies across North America as far as Arizona, but apparently not into Mesoamerica (Maschner et al., 2013).

Amerindian Connectivity

What impediments prevented Amerindian societies from keeping pace? First, size: the Americas are considerably smaller than the rest of the world, housing only c. 20% of the world's population by 1491: fewer innovators and borrowers. Next: connectivity. Isolation from the Old World was compounded by internal isolation created by various geographic barriers. In Jared Diamond's famous argument, the principal axis of the Americas is north-south, along which environments varied more rapidly across shorter distances, meaning that domesticated crops did not easily spread far from their origins (Diamond 1997; Allaby et al. 2015; Fig. 2). From the main cradle of Mesoamerica, corn, beans and squash waited millennia to take root in Arizona (Diamond 1997).

The major centres of Mesoamerica and the Peruvian Andes, originated in high plateaus that did not enjoy long, easily navigable riverine contact with their coasts, in contrast to say Egypt, Mesopotamia, the Indus valley, China or Europe and Russia, where riverine communication was of major importance since the earliest times. Only the Maya and some Peruvian societies had coastal cities; Andean cultures did sail along the Pacific Coast (Mann 2005), but Incas and Aztecs seemed unaware of each other's existence. Donkeys helped connect Mesopotamian centres and other hinterlands more intensely to Mediterranean shores across arid and elevated barriers (Broodbank 2013); llamas – the only working domesticate other than dogs in the pre-Columbian Americas – performed a similar service in Peru, but not between the Mexican plateau and Caribbean coasts.

The Incas built many roads of course and established long-distance communication networks of human runners and load-bearing llamas. Connectivity was enough that smallpox was able to spread from Mexico to the Andes and generate pandemic before the arrival of Europeans, but not so much that the Andean llama ever met the Mesoamerican wheel, which seems only to have been used as a children's toy. Aztecs' and Incas' mutual isolation gave Spaniards a vital information advantage, particularly Pizarro over Atahualpa at Cajamarca (Prescott, 1847).[23]

Lesser centres were even more remote, and separated by harsh environments: Mississippi, Oasisamerica, the Amazon basin, but again were well-enough connected that many had been witnessed only briefly or not at all by Europeans before, some suspect, post-Columbian disease had already wreaked havoc (Scarre 2005, Mann 2005).

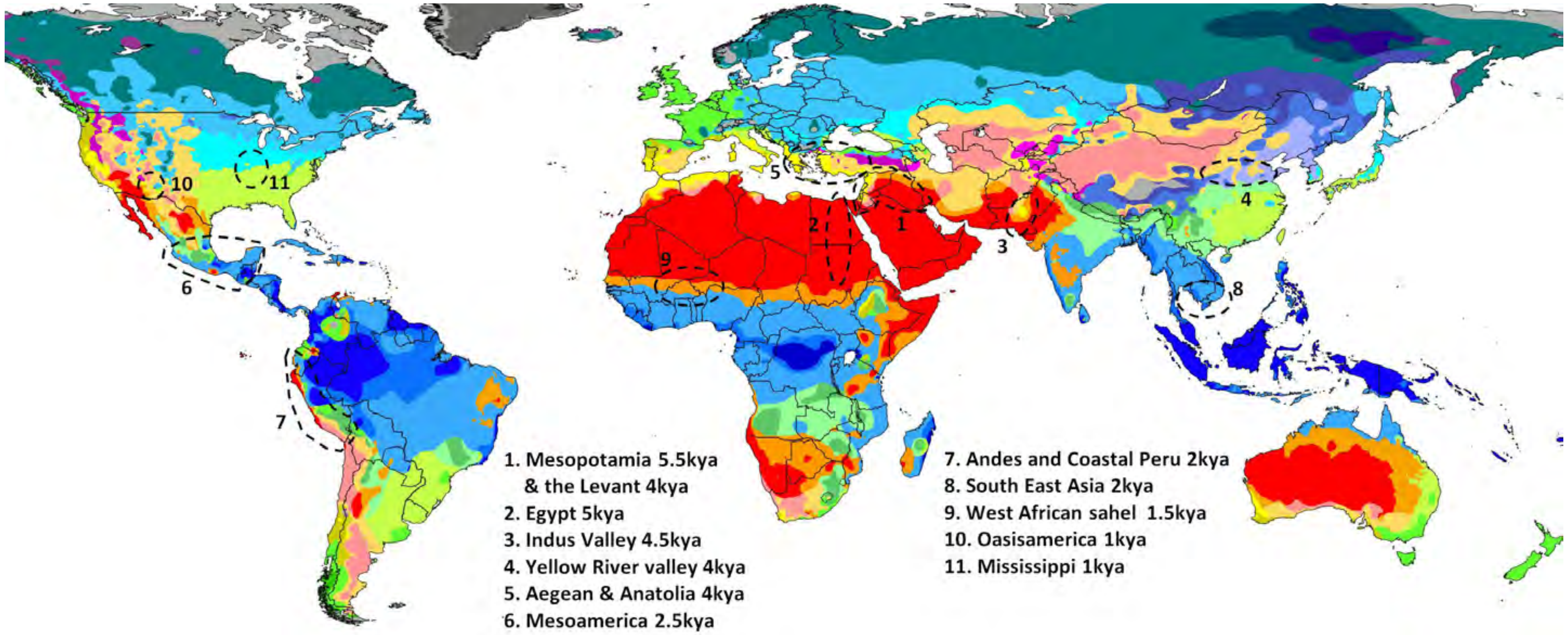

Fig. 2: World map showing Köppen-Geiger climate classification by Peel, M.C. et al. (2007), with early civilizations and approximate origin dates overlain by Philip Day (2017). New World civilizations emerged in areas where climate ariation impeded the spread of domesticated crops beyond their zones of innovation (Diamond 1997; Allaby et al. 1995); they also emerged later.

23 Had Atahualpa been aware of the Spanish conquest of the Aztec Empire, in particular Cortes' tactic of kidnapping Moctezuma, he would have more likely ambushed and killed Pizarro's men and certainly would not have allowed himself to be exposed with an unarmed retinue at Cajamarca. Pizarro on the other hand drew inspiration from, and learnt from the success and mistakes of Cortes in Mexico (Prescott, 1847). Such naivety on the part of Atahualpa, due to an information disadvantage vs the more mobile Spaniards, is analogous to that of the aboriginal American megafauna in the face of the first human colonisation c. 11kya.

Disease Asymmetry

Why there was such an asymmetry in disease experience between Amerindian and European peoples c. 1500 C.E. is one of the central questions of this paper. It can be split into two components: why did Amerindian populations suffer so heavily, and why did Europeans (and other Old World populations) suffer so little in response?

The first component is probably the more straightforward. Humans colonised the Americas towards the end of the last Ice Age c. 15,000 years ago, when conditions briefly permitted.[24] These hunter-gatherers were subsequently cut off from the rest of the world when the Ice Age ended and sea levels rose, several thousand years before agriculture or civilization appeared anywhere.[25] Therefore, as successive diseases in the Old World emerged, spread, killed, lost virulence and co-adapted to their human hosts, they formed great shared disease pools that spanned the webs of human interaction that reached across Eurasia and Africa, but not into the Americas (McNeill, W. H., 1976; McNeill, W. H. and McNeill, J. R., 2003). Locally and temporarily, the demographic impacts of new disease exposures for Old World peoples could be catastrophic; over time however, populations recovered with improved immunity, and gradually acquired a growing array of endemic pathogens of generally tolerable or negligible virulence among Europeans, but lethal to Amerindians.

We might expect that the extremely dense urban populations, such as those of Tenochtitlan in today's Central Mexico, and in particular those in low-altitude tropical regions such as Chan Chan in coastal Peru, or Mayan cities surrounded by jungle, would have made ideal conditions for communicable human disease to thrive. Indeed, smallpox reached and ravaged the Incan lands before Spaniards themselves made it that far. Apparently however, such conditions were not *sufficient* for new diseases to *emerge*, at least not of those which can cause large epidemics or pandemics.

Did Amerindians suffer disease at all? We know from skeletal and microbial genetic evidence e.g. from graves, coprolites, etc., that Amerindian populations certainly experienced disease and parasitism before the European encounter, particularly of protozoan, multicellular and arthropod varieties, but less so of viral or bacterial infections (Martin and Goodman 2002; Darling and Donoghue 2014). Syphilis we have mentioned as having emerged in the pre-Columbian New World; the *Treponema* bacteria responsible might have evolved from that which causes yaws, having travelled with the first colonists (Rothschild 2005); it is related to benign gut bacteria found in rural Africa and ancient Mexican coprolites (De Filippo et al. 2010; Tito 2012), so might have emerged spontaneously. Viral infections that we know of (herpes, HLTV) are also venereal and travelled with the first colonists – 'heirloom' diseases (Gentry et al. 1988; Li et al. 1999). We know of at least one later pre-Columbian transfer from the Old World, an unusual case of human-to-animal-to-human zoonosis: a strain of tuberculosis transferred from Africa to coastal Peru and Chile via Atlantic seals, at or before 1000 C.E. (Bos et al. 2014). It is not clear to what extent this TB spread throughout the Americas; skeletal lesions and ancient DNA evidence have also been found in North America, physical deformities indicative of TB were frequently depicted in Mayan art (Mackowiak 2005); TB therefore might have *also* migrated with the first colonists, but pre-Columbian strains were later displaced by more virulent European imports (Bos et al. 2014).

We are yet to find evidence of any human-to-human communicable disease native to the Americas that was aerosol-borne or otherwise capable of causing lethal epidemic. The imported TB left a record in individual skeletons but not of death on a mass scale (Bos et al. 2014). While native viral pathogens might not leave a record in skeletons or coprolites, the absence of evidence of any other type

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24 The exact details are still being worked out (e.g. Achilli et al., 2013) but should not impact the arguments of this paper.

25 The only known contact before 1492 occurred when Norsemen of Greenland explored Vinland (now Canada) from c. 1000 C.E., but this contact was fleeting and of no lasting importance. Araujo et al. (2008) claim that Amerindian tapeworms constitute evidence of a later, non-Beringian migration, because the worms could not survive in the Beringian environment; this is not considered in the review by Achilli et al. (2013). Indirect contacts supplied archery technology (Maschner et al. 2013; see above) and tuberculosis via seals (Bos et al. 2014; see below). Apart from these fleeting contacts, Amerindians might as well have migrated to another planet. These observations raise another set of enormous questions which are unfortunately beyond the scope of this essay: in what ways did the development of New World and Old World complex societies follow similar or divergent lines to each other, and why? Why did they develop at all? The fact that complex agrarian civilizations with social hierarchy, religion, organised warfare, trade, commerce, etc. emerged independently multiple times, ultimately from hunter-gatherer populations in completely unconnected parts of the planet is arguably one of the most pertinent questions in the field of history.

is conspicuous: mass graves, Amerindian texts where records survived (Aztecs, Maya), documentary evidence after 1492, modern epidemiological or genetic evidence which might be available if such pathogens survived. We therefore conclude that not only did Amerindians not possess any human-to-human communicable diseases capable of causing lethal epidemic among Europeans, it is unlikely that they suffered such pandemics themselves, particularly of aerosol-borne viral pathogens. This requires explanation.

Causes of the Disease Asymmetry

We have seen that major communicable diseases in humans have derived both from our symbiotic and commensal microbes, and from a range of zoonotic sources, particularly livestock, primates, rodents, bats and birds (**Table 1**; **Appendix A;** Wolfe et al. 2007). Of that list, livestock are the outstanding under-represented category in the Pre-Columbian Americas, which raises suspicion. It remains a puzzle why Amerindian primates, rodents, bats and birds did not supply more ancient zoonoses. They do today: for example, North America is a current rodent zoonotic hotspot (Han et al. 2015; Han et al. 2016); much of South and Central America likewise constitute a bat zoonotic hotspot (Han et al. 2016), and were well-populated in pre-Columbian times by humans who engaged in ecologically-disruptive activities, including Amazonia (Scarre 2005, Mann 2005).

The absence of primate zoonoses might be the easiest to explain: New World monkeys split from Old World primates c. 30mya so relatedness is not a factor; they are mostly arboreal and tropical so their synanthropy is weak at best, and late. Birds, bats and rodents are harder to account for; perhaps the loss of wildlife diversity generally had some impact, by disrupting parasite-host networks, reducing sympatry generally, or by eliminating potential livestock amplifiers and conduits. Above, we suggested livestock act as pivots between zoonotic-rich networks of birds, bats and rodents, and highly-connected human webs conducive to zoonotic emergence. Perhaps with better data and new analytical frameworks being developed we might be able to generate some testable hypotheses in the future, but for now most specialist attention is understandably focussed on explaining and predicting modern-day patterns of zoonosis, or otherwise not focussing on the question of New World exceptionalism (Engering et al. 2013; Morand et al. 2014; Anderson and Sukhdeo 2011; Gomez et al. 2013; Luis et al. 2015). The response of this paper will therefore be incomplete; the best we can offer is to elaborate the importance of lower levels of wildlife diversity, domestication, and connectivity among human societies in the New World compared to the Old.

The only large mammal domesticated by Amerindian populations is the llama, restricted in historical times to the Andean altiplano, compared to 14 domesticated species in the Old World. This is partly due to Amerindians having fewer potential options for selection, and because domestication is a gradual multi-stage process that depends on the animal in question possessing a number of traits that are unusual in combination as well as on fortuitous environmental conditions, and therefore is generally unlikely (Budiansky 1994; Diamond 1997; Diamond 2002). The dearth of options can be traced to the great megafauna extinction coincident with the first colonisation of the Americas; we return to this event and the role of the continents below.

High altitudes are not conducive to disease exchange, and as far we know people did not keep llamas indoors (or even in bed), as Old World people sometimes did with lambs, piglets, etc. We discussed above the lower intensity of interaction among regions of the New World and the fact that the llama did not reach Mesoamerica. In contrast, the 'major five' domesticates of South West Asia (horses, cattle, sheep, goats, pigs) were adopted across Africa and Asia before 1500 C.E., fuelling, for example, the Bantu expansion through central Africa or the emergence of cavalry empires from Manchuria to Mali (Diamond 1997).

The case of smallpox is illustrative. The most recent review (Babkin and Babkina 2015) argues that smallpox derived from camelpox c. 4kya, and that camels acquired it from the naked sole gerbil in the Horn of Africa, camels having been introduced there by humans at that time. These gerbils and camels had not previously been in contact anywhere in the world. Camelids originally evolved in the Americas and migrated to Asia c. 3mya, before becoming extinct in their native continent with the arrival of humans.[26]

Smallpox is one of c. 10 major *orthopoxviruses* worldwide, of which three are native to the Americas: racoonpox, skunkpox and volepox viruses;[27] racoonpox has been observed to cause human infection in the lab (Gubser et al. 2004; Emerson

26 This is also true of equids.

27 Above, we mentioned squirrelpox originated in North America; it belongs to a related genus, the parapoxviruses, which cause only rare and minor infections in humans.

et al. 2009). We will never know whether there were other orthopoxviruses that went extinct with American megafauna hosts, but thanks to the New World's lower species diversity and weaker internal connectivity, there were *fewer opportunities for novel contacts among mammalian species and between mammals and humans*. Eventually, a human orthopoxvirus emerged in the Old World but not in the New; it happened to become humanity's most lethal infection, and spearheaded the biological assault on Amerindian peoples after 1500 C.E.

We saw above that measles (emerged c. 1kya) made a similar journey, ultimately from bats via cattle (as rinderpest) to humans (Drexler et al. 2015); but the date and geographical origin of rinderpest remain unknown. We also saw the dynamics of wildlife-livestock-human emergence pathway in the case of Nipah virus, which might serve as a model for ancient smallpox and measles. Perhaps the Andean llama could have picked something up from Amazonian bats, but not were translocated far enough in that direction by their human partners.

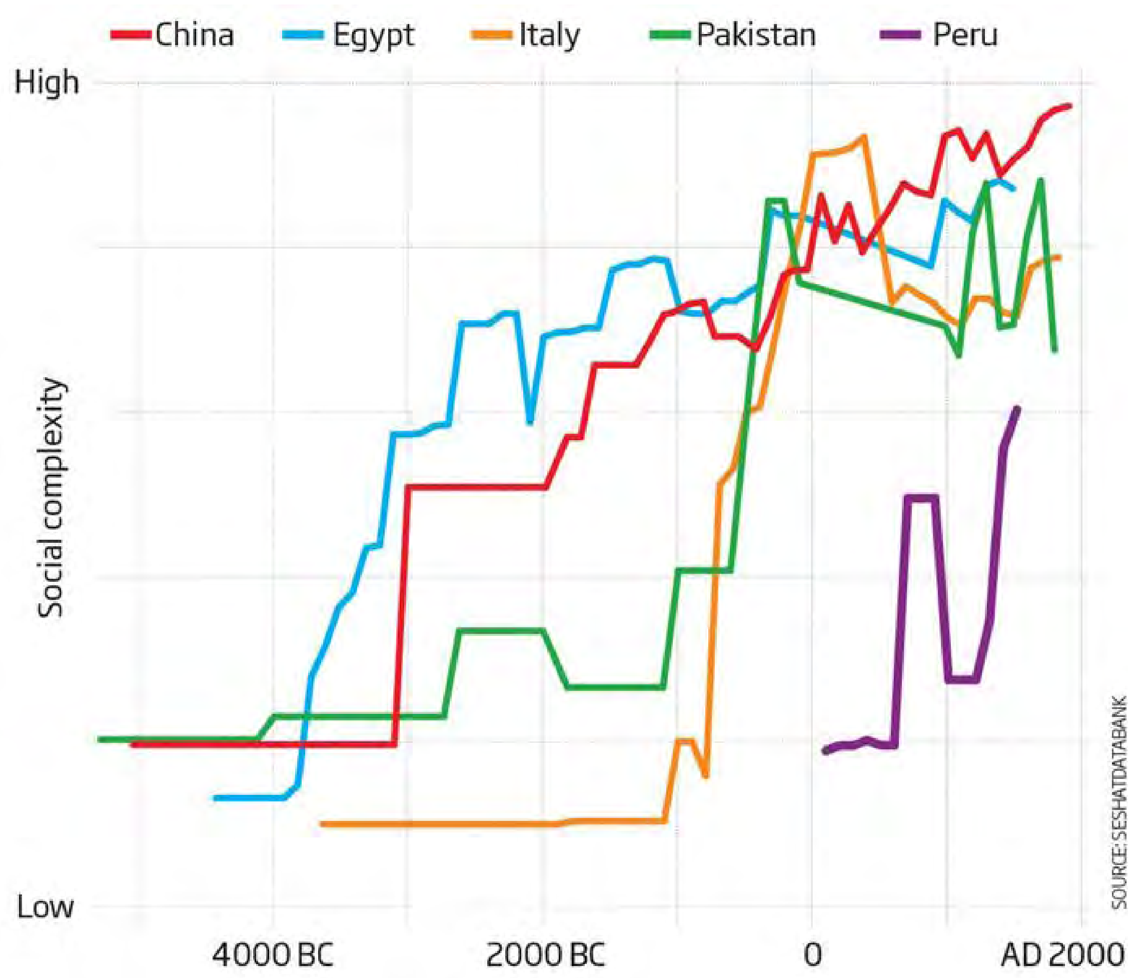

Fig. 3: Rise and fall of social complexity using 53 markers tracked in the Seshat historical database http://seshatdatabank.info, from a forthcoming article by Peter Turchin et al., previewed in the New Scientist *(Spinney 2016). Note the much later and lesser rise of social complexity in Peru compared to sample Old World regions.*

Finally we note some other arguments about Amerindian people. Black (1992) argued that the Beringian population bottleneck (c. 5k people?)[28] entailed narrow genetic diversity among the first American colonists and their descendants to 1492; with decreased host antigen diversity, pathogens adapted to one human host would spread more rapidly to the next, increasing the transmission rates of epidemics. We have not seen this suggestion repeated; it does not feel necessary given (a) the wide array of the invading pathogens and (b) their high death rates on first exposures in Old World societies. More recent scholars, considering North American native peoples, argue that populations crashed catastrophically and failed to recover because of declined nutritional intake related to disruption to their traditional food ecology (horticulture + hunting and gathering) associated with colonial expansion (Martin and Goodman 2002; Mailer and Hale 2015). If this argument is correct, we might expect a similar effect caused by the disruption of early Spanish Empires in Central and South America, with brutal forced labour, movement of peoples, etc. It sounds like a testable hypothesis.

Quite possibly a complete answer will include a little bit of all the points considered above, including time – perhaps more deadly pathogens would have emerged eventually in the pre-Columbian Americas if complex societies had existed for longer before contact; Fig. 3 illustrates they lagged Old World equivalents by several millennia. For now, we point to lower wildlife diversity and near-absence of livestock, and generally weaker connectivity in the New World, as reducing opportunities for novel contacts among mammalian species and between mammals and humans, and therefore lowering the probabilities of spillover and emergence events. Next we consider the loss of wildlife and consequent dearth of domesticate potential, finding ultimate causation in continental geography.

Megafauna Extinction and the Continents

Why did Amerindians have few options for domestication? The 'Quaternary Extinction' event saw a spike in megafauna (animals over 40kg) extinction globally,

28 *Achilli et al. (2013) discuss the latest thinking on the makeup of the human groups who first colonised the Americas.*

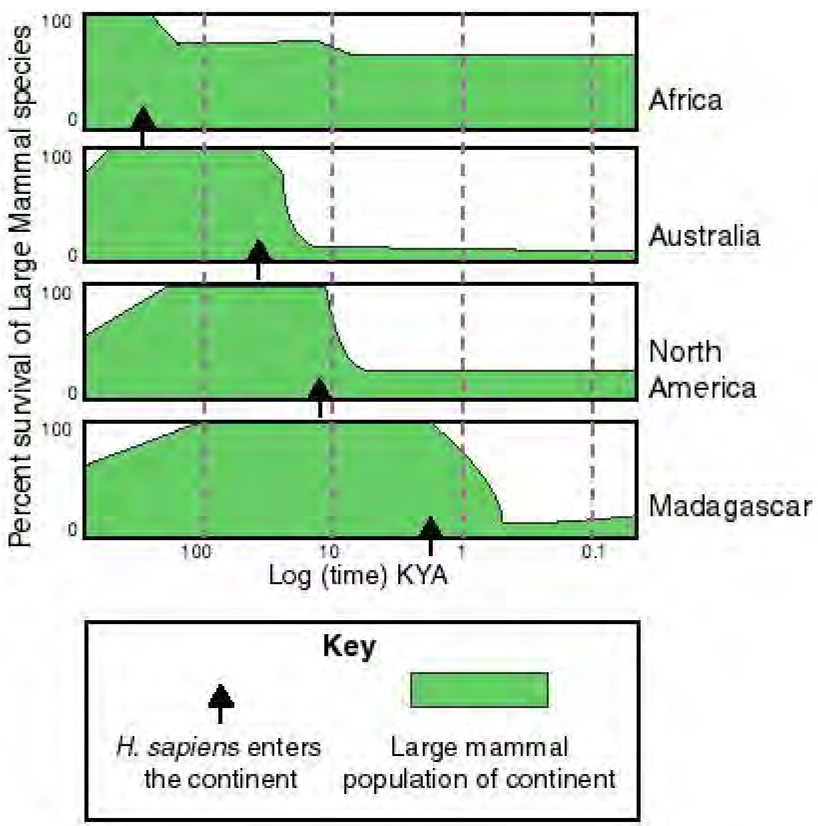

Fig. 4: Extinction rates by selected continents following arrival of Homo sapiens; Elin Smith (2006) using data from Martin (1989)

beginning c. 12kya. Causes have been debated, including climate change, human 'overkill', or perhaps some feedback effects (Dought et al. 2010), but recently seem to have been settled in favour of the human factor as dominant, with climate change also important (Sandom et al., 2014, Bartlett et al., 2015). Fig. 4 provides an illustration by Elin Smith (2006)[29], using older data derived from Martin (1989).

Extinction rates varied by continent but were highest in Australia and in the Americas, which were isolated for longest and where humans arrived latest (c. 40kya and 15kya respectively).[30] In the Americas, 103 of 132 genera went extinct, compared with 24 of 46 in Asia and 8 of 50 in Africa. American losses included all of the equids and many camelids, clades which in Afro-Eurasia yielded valuable pack, draught and transport domesticates that boosted productivity and connectivity. Camelids survived to be domesticated in the Andes (llamas, alpacas) but not elsewhere in the Americas.

29 https://en.wikipedia.org/wiki/File:Extinctions_Africa_Austrailia_NAmerica_Madagascar.gif

30 *Sandom et al. (2014) suggest arrival time of the Homo genus generally is important, i.e. African and Asian megafauna might have evolved wariness of bipedal apes from contact with Homo erectus and other hominids*

Why Europe?

We have already considered how Europe was able to develop rapidly from c. 1000-1500 C.E. thanks to borrowing heavily from African and Asian heritage, mostly via the Muslim world. It would take arguably several centuries before Europe surpassed Old World rivals in terms of economic sophistication (Pomeranz 2000; Currie 2014), but in the meantime by 1500 if not long after, she took a lead in shipping and firearm technologies conducive to the projection of global power. Being a heavily-indented maritime region (Cosandey, 2002), with a high ratio of coast length to land area, plus many large, slow-moving rivers, investment in maritime activity had always yielded returns since earliest times. The tough and unpredictable currents and winds of the North Sea and Atlantic seaboards demanded innovation of more robust shipping and manoeuvrability in high swells and changeable winds; ships robust to Atlantic swells were able to absorb the recoil of larger cannon with greater range, enabling them to defeat foreign armadas of superior size with ease (McNeill, W.H. 1963 and 1974).

Political fragmentation played an important role, engendering fierce interstate rivalry, and also precluding the sort of decisions made by the Ming and Qing Emperors of China which shut down Zheng He's great enterprises (1433) and later the Fujian sealords (1680s, see below). But possibly the most important factor was closer proximity to the Americas, by a factor of two to four.[31] Even if Columbus' rash and serendipitous venture (Bernstein 2008) had not been undertaken, it is not unreasonable to suggest that other discoveries would have occurred before long.[32]

Microcosm: 17th Century Fujian

The case of the Chinese province of Fujian in the mid-17th century is indicative

31 *Sevilla to Havana is 4,571 miles; west Africa to Brazil is only c.2,000 miles; Shanghai to the west coast of Mexico is 7,700 miles for comparison (Google Earth).*

32 *Cabral discovered Brazil (1500) while sensibly following south west-ward currents to accelerate his mission to India. Basque or English sailors in pursuit of cod and whales in the north Atlantic might have eventually discovered Newfoundland (1497), recapitulating the Vikings' ancient journeys, even without knowledge of Columbus' landfall (Fagan 2007). Arguably Europeans discovered the Americas three times (the Vikings, Columbus, Cabral), and perhaps even four if claims of Bristol sailors' contact in 1480 are correct. The salient point is there were more European feelers being extended into a smaller ocean than there were Chinese outings in the much larger Pacific.*

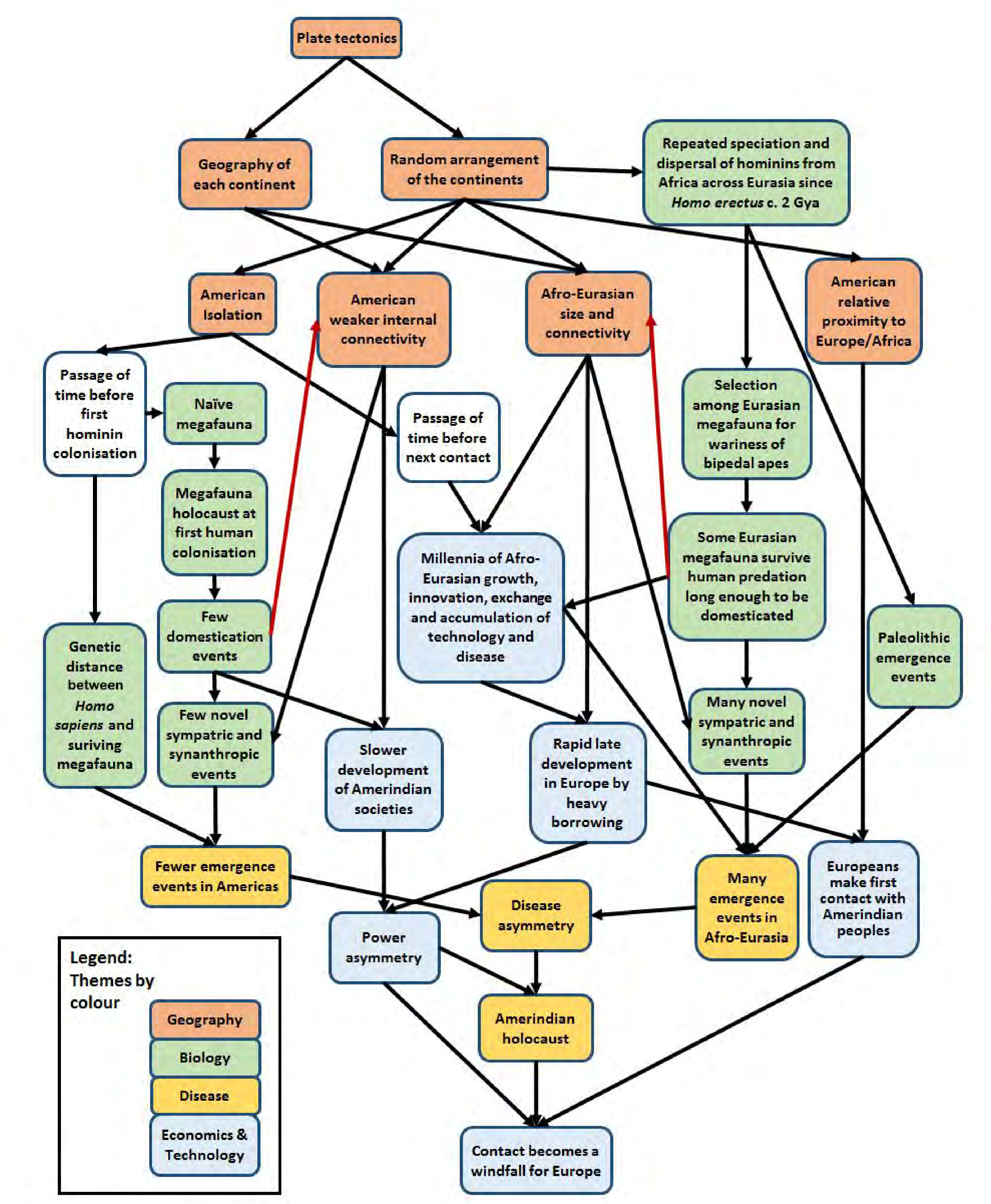

Fig. 5: Schematic diagram representing many of the arguments of this paper, mapping the causal pathways that link plate tectonics to the American megafauna extinctions, asymmetrical Columbian exchange and, ultimately, the Amerindian Holocaust and 'Windfall' outcome for Europeans. Note that certain arrows (red) point upwards. Philip Day, 2017.

of several themes we have discussed so far, including biological exchange (crops and disease), conscious borrowing of technology, and political fragmentation vs unity. Fujian, a marginal province of Ming China (1368-1644) rose under a succession of private warlords as the Ming disintegrated, attempted to challenge the Dutch at sea and succeeded in the capture of the latter's colony of Formosa, before finally being brutally absorbed into the Qing Empire (1644-1911), by 1683, the latter acting in alliance with the Dutch (Andrade 2011; Ho 2011). Fujian prosperity owed much to the sweet potato, a crop of Andean origin recently smuggled from the Spanish Philippines. The great sealord Koxinga died less than a year after conquering Formosa (1662), possibly of syphilis (Andrade 2011), another American import that utilised European vectors (Boomgaard 2007)[33], and thus the Spanish Philippines were spared his imminent predations (Andrade 2011). Fujian state naval building was one of very few serious attempts by non-European states to challenge Europe at sea, by copying their designs; none succeeded until Japan defeated Russia in 1904-5. Just like those of Mysore in India during the 1760s, crushed by the British EIC (Washbrook 1988), Fujian's efforts came during a brief moment of political fragmentation in a great Asian core region.

Summary: Continents

We have seen that the nature of the continents – their distribution and internal geographies – influenced the course of world history through a complex causal pathway; this is represented diagrammatically in Fig. 5. Africa, Asia and Europe enjoyed better connectivity, both among and within themselves, than did the Americas (or Australasia). Long experience of interaction with hominids permitted enough mammals to survive to the Holocene and provide more potential options for domestication, resulting in a larger array of mammalian partners that played roles in production, transport and perhaps most fatefully disease transfer. Longstanding American isolation entailed late hominid colonisation (c. 15kya) and a megafauna fatally naïve to the threat of the new superpredator *Homo sapiens*.

33 Syphilis spread rapidly throughout the Old World after its introduction to Europe by Columbus' men; it reached India perhaps as early as 1498, Canton by 1506, and Java (later Dutch Batavia) by 1520, becoming widespread there by 1580 (Boomgaard 2007). Therefore the chain of infections might conceivably have reached Koxinga via the Dutch and local Formosans, but more likely from China if suspected early (1654) symptoms are correct.

Greater endowments of size, connectivity and domesticates also generated a power imbalance between Old and New World peoples that yielded advantages of weaponry, mobility and information to the former.

The span of the Atlantic was large enough that by the time contact was made between peoples of the Old and New Worlds, the former had built up an arsenal of communicable diseases lethal to the latter, and suffered only syphilis in response. Multiple subsequent pandemics facilitated conquest and consolidation, continued dominance, exploitation, and migration in such a way that enriched the Old World societies that made first contact, and perhaps relieved Europe generally of catastrophic population pressure. The naivety of American megafauna was thus recapitulated by Amerindian immune systems, and at critical junctures, by their societies' leaderships.

But the Atlantic gulf was also much smaller than the Pacific, which, along with other factors, greatly increased the likelihood of first contact being initiated by Europe, rather than by China or any other Old World rival. In the event, Europe received an enormous windfall which facilitated her rise to world dominance by 1900.

Modern Disease and Medicine

This section considers human encounters with disease in the last c. 100 years, which includes for the first time well-organised and scientifically-based medical responses.

We should note some successes of cultural evolution outside the medical profession and long before this time. Various customs and taboos help us keep our distance from microbes; Wesley's phrase, 'cleanliness is next to godliness' is of ancient provenance; we saw above hardening conservative sexual mores in Europe as a possible response to syphilis (Boomgaard 2007); below we mention Manchurians' aversion to sickly marmots, which carried Plague (McNeill, W.H. 1976). In fact, instinctive hygiene behaviours are widespread in the animal kingdom and perhaps basal; our own disgust emotion interacts with culture but predates it (Curtis 2007). Professional medicine has an ancient history, but before it absorbed the scientific method, it added little to the crude empiricism of biological and cultural evolution, and neglected useful traditional pharmaceutical knowledge

(Schiebinger 2004). The role of doctors was primarily psychological, 'strictly comparable to that of the priesthood' (McNeill, W.H. 1976). Some noteworthy exceptions include the policies of quarantine, which imperfectly[34] restricted the spread of plague in Italy by c. 1500, or state-sponsored inoculation campaigns against smallpox, e.g. in China by 1700 if not earlier (Silverstein 2009), also leprosaria, plague pits, etc.

After 1900 and 1950

In the late 19th century, the expansion of steam shipping, the great canals, and railways accelerated the intensification of connectivity among the global web which had been first established c.1500; the new infrastructure was largely complete by 1900 or shortly thereafter (e.g. Suez Canal 1869, USA Transcontinental Railroad 1869, Trans-Siberian Railroad 1904, Panama Canal 1914), linking diverse hinterlands more closely than ever before. After 1945, commercial passenger aviation expanded rapidly; the world's airline networks continue to grow today, with increasing routes, cities, flights and passengers. Both of these events introduced new opportunities for communicable disease in a manner similar to older integration events in the human web: the Silk Road c. 2kya, *Pax Mongolica* c. 1300 C.E., Columbian Exchange c. 1500. Simultaneously, population densities soared from c. 1bn in 1900 to 7bn today, and the largest cities from c. 6.6m in 1900 (London) to 33m today (Tokyo), the greatest demographic boom since agricultural revolution; emerging megacities with poor sanitation present a particular hazard (McNeill, W. H. 2007). Similar trends are seen in livestock: animal protein production increased 7-fold between 1950 and 2011; 21-fold in case of poultry (Larsen and Roney 2013). We consider some particular disease emergence events below.

At the same time, both medical science worthy of the term, and effective public health authorities, emerged for the first time by 1900, neatly coinciding and interacting with the closure of the steel-powered web (see 'Yellow Fever' below). Key innovations included the germ theory of disease (accepted after 1890), virology and vectors (by 1900), evidence-based medicine; later came antibiotics and their industrial production (1943), genetic sequencing (human genome by 2003), etc. By 1900, public health bodies enjoyed much improved knowledge, communication, resources and authority.

The shifting balances between new opportunities and barriers to disease have produced contrasting outcomes, including some novel pathogen strategies. The 20th century has seen some of the largest (in absolute terms) pandemics in history (Influenza in 1918, c. 50-100m dead; HIV/AIDS since c. 1970, c. 39m dead) as well as, regionally at least, probably the lightest burdens of infectious disease since hunter-gatherer times; in our foreseeable future, realistic outcomes include both the eradication of most infectious diseases (Oxford 2008) and catastrophic pandemic (McNeill, W.H. 2007; Smil 2008).

Exemplary Episodes

Cholera, 1854. John Snow used systematic analysis and pioneering data techniques to investigate and resolve cholera outbreaks (Hempel 2013); cholera's terrifying nature was sufficient finally to overcome the objections of property owners, who up to this point had blocked development of London's sanitation infrastructure.

Yellow Fever, c.1900. U.S. army doctors utilise the latest techniques in virology and methodological, if dangerous, experiments to unravel the complex human-mosquito lifecycle of the virus[35]; the U.S. won the Cuban War of Independence (1898) and completed the Panama canal project (1914), which had been failing under French leadership 1881-94 due to a catastrophic disease death toll (McNeill, J.R. 2010; Oldstone 2010).

Black Death, 1911. It is not well known that the pathogen behind medieval Black Death nearly caused another global pandemic in the twentieth century. The collapse of the Qing Dynasty in 1911 permitted legions of Chinese fur hunters to seek their fortunes in Manchuria, where they disregarded local customs not to approach sick marmots, a reservoir for *Yersinia Pestis*[36], the bacterium famous for medieval Plague. The ensuing epidemic transferred rapidly to port cities around

34 *The role of rats and fleas as vectors was not known; rats could escape along mooring ropes.*

35 *A twist is that the virus is not infectious in the mosquito for several days after biting a human host; at least one scientist died experimenting on himself, lured into danger by this viral con (Oldstone 2010).*

36 *Local people did not have knowledge of bacteriology or of Black Death; to hunt, skin or eat a sick marmot was considered (correctly in a way) 'unlucky'.*

the world; a third[37] global pandemic was averted only by the quarantine actions of multiple health authorities in these cities. Two key innovations led to complete success, where earlier authorities enjoyed mixed results: the vector and life cycle were properly understood (earlier, rats could escape quarantined ships along mooring ropes), and the telegraph provided an information advantage: for the first time, news could travel faster than a pathogen (McNeill, W. H. 1976).

Typhus, 1914-18. De-lousing stations which successfully eliminated the vector of typhus became standard in armies of the Great War; for the first time in history deaths by weapons outpaced death by disease in a major campaign (McNeill, J.R. 2010).[38]

Influenza, 1918. A product of the dense barracking, extensive mixing and long-distance movements of men of diverse backgrounds during the Great War; 'Spanish Flu' (a misnomer) infected 500 million people in 1918, killing 50-100m, c. 3-5% of world population. Origins are debated, with either rural Kansas or a British mustering station in France near the Western Front the leading contenders, displacing earlier Asian-origin theories (Oxford 2001, Barry 2004). Spillover from birds, possibly amplified by pigs, is suspected. Pneumonia is identified as a common accomplice in fatalities, caused by bacterial infection of lungs weakened by influenza. Both authors stress the salient point is not the exact location of origin, but the fact that spillover *anywhere* can lead to global pandemic. Fresh spillovers are always likely due to influenza's mutability.

HIV/AIDS spillover, 1908; pandemic since c. 1970. Infection with the highest death toll in the modern world, with near 100% fatality untreated, but with a long ~10-year incubation period; c. 39m people have died since 1980 and 37m infected today. David Quammen provides an excellent fictionalised reconstruction of the spillover of HIV in rural Kenya and its establishment as a minor but enduring epidemic in Leopoldville (Kinshasa), before emergence as pandemic since the 1970s (Quammen 2012)[39]. Spillover happened probably due to contact between a bushmeat hunter's open wound and a chimpanzee carcass in remote upcountry Congo, in 1908; it occurred at least twelve times. Thereafter it was able to journey, perhaps in a single person's body, downriver to Leopoldville thanks to the penetration of global trade into the most remote parts of the earth. The transmission rate during heterosexual intercourse is low; the virus could persist only because of a large urban population and probably also because of the rates of prostitution in a colonial boom town; other venereal diseases such as genital ulcers boost transmission, perhaps critically (De Sousa et al. 2010). Thereafter, HIV enjoyed several serendipitous interventions associated with modernity: amplification by needle re-use during inoculation campaigns against *other* pathogens c. 1920s-50s (HIV's slow incubation period here was surely vital so that its human hosts did not appear to suffer from any infection, which would have precluded them from needle sharing)[40]; travel to Haiti; amplification by blood plasma collection and resale in Haiti c. 1971-2 (these products were screened for known pathogens only); finally, the expansion of air travel which brought it into the USA and rapidly throughout its commercial aviation network and sexually liberal (particularly homosexual) communities, and later to the world's attention by 1980 (fully diagnosed and understood by 1986). HIV's evolutionary success in this episode was a rare counter-attack against modern science's otherwise very successful advances against disease c. 1900-75.

Nipah virus, 1997. Malaysian farms kept pigs close to mango trees, whose fruit are eaten by bats; pigs picked up Nipah from the leftovers before transferring to humans; see main text above for more detail. This case provides an excellent opportunity to observe the dynamics of wildlife-livestock-human multi-phase emergence (Pulliam et al. 2012).

SARS, 2003. Rising consumer affluence fuelled the 'Era of Wild Flavours' in south China, which saw an increasingly exotic array of wildlife housed in unsanitary, cramped pens in the markets and restaurants of Guangzhou. Bats appear to be the ultimate origin. Global air travel rapidly lead to outbreaks in Hong Kong, Singapore, Beijing and Toronto, with fatality rates of c. 10%, before containment. Medical personnel were particularly susceptible, with 400 infected in Beijing alone, raising the prospect that medical services could become

37 Previous pandemics include the Justinian Plagues (beginning 540s C.E.) and the famous medieval Black Death (beginning 1340s, with echoes as late as 1771 in Moscow); there might have been even earlier events (Kohn 2008; Appendix A).

38 On the Eastern front, facilities were not everywhere available and several epidemics occurred, particularly in Serbia, and afterwards in the Russian Civil War during which c. 3m civilians died of typhus.

39 See also https://en.wikipedia.org/wiki/History_of_HIV/AIDS.

40 Doctors did understand the risks of needle-sharing for transmission of other pathogens, but needles were scarce and expensive, so were re-used when patients appeared healthy.

overwhelmed. SARS sufferers display symptoms before becoming infectious, in contrast to influenza. (Quammen 2012).

Influenza, 2006 and 2009. Minor pandemics causing c. 100k deaths occurred in 2006 ('Bird Flu') and 2009 ('Swine Flu') following mutations and fresh spillovers. The former event has been traced to migratory wild birds via poultry farms in China, and the strain has been distributed among bird populations globally.

Polio, 2013. Epidemiologists declared the end in sight nearly a decade ago (Oxford 2008), but polio erupted in Syrian refugee camps in 2013, a product of civil war. It appears to be under control there and on the retreat but holding out in certain parts of west Africa, Pakistan and Afghanistan, where vaccination campaigns have been resisted due to regional mistrust of central authorities.

Ebola, 2014. Ebola is a haemorrhagic fever caused by a virus whose natural reservoir is a tropical fruit bat of West Africa. First coming to the world's attention in 1976 but generally lying low with sporadic local outbreaks, a regional epidemic flared up in 2014 in several West African countries. In Guinea in particular, a custom of touching the dead helped its spread. Public information campaigns, well-organised medical facilities, hard work and bravery of medical staff and an international effort helped eliminate the disease in most countries affected by March 2016, with 11,000 deaths. Ebola's symptoms were highly visible, the disease progressed quickly and its lifecycle was well known; it stood little chance against well-resourced medical services.

Tuberculosis, 21st Century. An ancient scourge and still the world's second biggest infectious killer after HIV, with c. 10m active infections and 1.5m deaths per year, Tuberculosis today exhibits a number of interesting evolutionary strategies including asymptomatic infection – astonishingly, one third of the world's population are thought to be thus infected. TB exploits the immuno-deficient niche created by HIV (accounts for c. 13% of infections). It is developing multi-drug resistance, where treatment has been incompletely or inadequately provided (Adams and Woelke 2014).

<u>Summary</u>

The examples discussed here illustrate a broad range of strategies displayed by pathogens, of both ancient and recent origin, to exploit novel opportunities associated with modernity. Several of these opportunities are of ancient precedent: increased connectivity and density of humans and livestock, ecosystem disruption, intimacy with animals, livestock-wildlife proximity, promiscuity, compromised immune systems, disruptions of war. Others are of novel types: needle-sharing, the blood plasma industry, partial exposure to antibiotics. Of particular intrigue are strategies of detection avoidance: long asymptomatic incubation, or 'latency' in the case of HIV; long latency and high rates of asymptomatic infection in the case of tuberculosis. The bacteria causing typhoid fever can remain asymptomatically infectious in the host after recovery from the initial disease.

The mutability of the aerosol-borne influenza constitutes an enduring threat: if a novel strain can combine high rates of infection and virulence with a longer period of light or no symptoms, it might be able to trigger a large pandemic before authorities could react. Genetic techniques and ever-advancing computing power might be expected to match the mutability of any pathogen before long, but containment will be harder the longer a pandemic has progressed before response is deployed; containment will be particularly difficult if medical personnel suffer high rates of attrition.

Appropriate responses to today's disease hazard therefore include a number of public actions: early detection systems located closer to source regions; vaccine specification and production machinery; stockpiles of known vaccines and medical equipment; legions of medically-trained personnel; prevention measures including education, ecosystem protection, antibiotic regulation, etc. The field of medical science does not want for knowledge or ideas (Parrish 2008; Dunn et al. 2010; Daszak et al. 2012; Flanagan et al. 2012; Rosenberg 2015; Han et al. 2015; Han et al. 2016; Geoghan et al. 2016); the question is whether sufficient international public resources will be committed to their direction.

Conclusions

We have considered communicable disease as a recurrent and powerful destructive force in inter-species interactions in the animal kingdom, in human relations with animals, and in interactions among human societies. If interaction acts as a – perhaps *the* – major, force of innovation and the rise of complexity in history, then disease constitutes a 'dark side' of interaction, less well considered historically perhaps than predation and warfare.

Asymmetries in disease burdens constitute a major driving force in human history, shaping the fates of human societies on all scales, most spectacularly the Amerindian holocaust, which lead to a 'windfall' event for Europe, and facilitated her rise to global dominance by 1900. We identified the distribution and geographies of the continents as the ultimate causal factors for why the particular Old World-New World disease and wider power asymmetries emerged.

The question of the relative absence of communicable diseases in the pre-Columbian Americas compels us to think harder about how and why such diseases emerge. Novel sympatric and synanthropic contacts seem to be important, along with ecological transformations, density, connectivity, etc. The role of livestock in linking human networks with the networks of special types of animals (birds, bats, rodents) might be critical, but we are unable to offer definitive answers.

Since 1900 and 1950, humanity has crossed new thresholds of density, connectivity and livestock ownership, and intrudes into natural ecosystems deeper than ever; in the past, crossing such thresholds has been followed by major disease emergence events and devastating pandemics; therefore we should consider our future prospects with caution. The historical perspective is probably not necessary for modern medical scientists in the fight against disease – they have plenty of data and powerful analytical methods to guide them – but it should emphasise for the general public the potential catastrophes that we might face if they fail. For students of the past, consideration of disease emergence and exchange is fundamental to understanding macroscopic patterns, trends and events in human history.

Appendix

Appendix A provides a summary of a subset of the major diseases of humankind, adapted and updated from Wolfe et al. (2007); we have restricted the list to biggest historical killers, added some more recent famous pathogens (Zika, Nipah, Ebola, SARS), and added some columns showing the region of origin, estimated date of emergence, and, in part (ii) below, our own comments and references; some data present in the original have been altered to reflect the latest literature.

Diseases in the Wolfe et al. (2007) original but omitted here are of the following origins: primates (hepatitis B, dengue fever, vivax malaria, visceral leishmaniasis), domesticates (diphtheria, rotavirus A), bats (mumps, possibly via domesticates), humans (pertussis/whooping cough) or both wild and domestic mammals (sleeping sickness, Chagas disease), or unknown (rubella, tetanus). All but Chagas disease are of Old World origin. Pathogens whose origins have been revised since 2007 include mumps, pertussis and tuberculosis, all formerly thought to be from livestock. Leishmaniaisis has been claimed to originate from gorillas (Hamad et al. 2015), but this has been challenged (Bastien et al. 2015), reminding us that the field remains fluid.

Appendix A (i): Major Historical Diseases, Pathogens and Origins

Sorted by order of estimated emergence, oldest first.

Disease	Agent	Pathogen Type	Route of transmission	Region of Origin	Likely Zoonotic Origin	Estimated Emergence Date
Tuberculosis	Mycobacterium tuberculosis	Bacterium	Human: aerosol	East Africa	Human origin	Ancestral species 2.8mya; virulent strains and diversification c. 10-5kya
Yaws, Syphilis, etc.	Treponema pallidum, multiple strains	Bacterium	Human: sexual, transplacental	Americas	Probably human origin; possibly African baboons	Yaws 1.5mya? Syphilis 8kya
Falciparum malaria	Plasmodium falciparum	Plasmodium	Vector: mosquitoes	Africa	Great apes, probably gorillas	400-30kya
Plague	Yersinia pestis	Bacterium	Vector: fleas Human: aerosol	China	Rodents	>= 5kya; pandemics from 1.5kya
Polio	Enterovirus: poliovirus	Virus	Human: faecal-oral	Old World	Human origin	>= 4kya; epidemics 200ya
Smallpox	Poxvirus: variola virus	Virus	Human: aerosol, skin	Horn of Africa	Camels, ultimately gerbils	4-3kya
Cholera	Vibrio cholerae	Bacterium	Human: faecal-oral	India	Aquatic environment and/or marine animals	>= 2.5kya

Influenza A	Myxovirus: Influenzavirus A	Virus	Human: aerosol	Old World	Ducks & pigs, ultimately wild birds	2.5kya; multiple events ancient and modern
Typhoid	Salmonella enterica var. typhi	Bacterium	Human: faecal-oral	Old World	Probably Human origin	>= 2.5kya
Yellow fever	Flavivirus: Yellow fever virus	Virus	Vector: mosquitoes	Africa	African primates (Genuon)	1.5kya
Measles	Paramyxovirus: Morbillivirus	Virus	Human: aerosol	Middle East	Cattle, ultimately bats	>= 1.1kya
Typhus	Rickettsia prowazekii	Bacterium	Vector: louse	Old World, unknown	Rodents?	>= 1kya
Common Colds	c. 200 known viral agents from several major families, inc: Rhinoviruses, Coronaviruses, HMPVs	Virus	Human: aerosol	Multiple, unknown	Rhinoviruses human origin; Coronaviruses birds and bats; HMPV birds	Rhinoviruses and coronaviruses unknown; HMPV as recently as 200ya
AIDS	Retrovirus: HIV-1	Virus	Human: sexual	Congo basin, Central Africa	Chimpanzee	1908
Zika	Flavivirus: Zika virus	Virus	Vector: mosquitoes Human: sexual	Uganda	African primates (Rhesus macaque?)	1952
Ebola	Zaire Ebolavirus	Virus	Human: contact with bodily fluids	Central Africa	Fruit bats	1976
Nipah	Henipavirus: Nipah virus	Virus	Contact with reservoir hosts	Malaysia	Pigs, ultimately fruit bats	1997
SARS	Coronavirus: SARS-CoV	Virus	Human: aerosol	South China	Civet, ultimately Bats	2003

Appendix A (ii): Major Historical Diseases: Notes and Sources

Disease	Comments
Tuberculosis	Strains of the human pathogen have an origin possibly 2.8mya, i.e. early in hominid history; the globally-successful pathogen of historical and contemporary infection went through a population bottleneck in East Africa c. 35kya (Gutierrez et al. 2005), then split in two lineages c. 30-20kya, which increased in virulence in Mesopotamia c. 10kya as human population densities increased, and expanded out of in multiple directions c. 10-5kya (Wirth et al. 2008, Brites and Gagneux 2015). Impacted early civilizations c. 5kya; reached South America at least c. 1kya, possibly via Atlantic seals i.e. human -> animal -> human zoonosis, might have also migrated with the first colonists; later displaced by European strains (Bos et al. 2014); skeletal lesions and ancient DNA evidence have also been found in North America, physical deformities indicative of TB were frequently depicted in Mayan art (Mackowiak 2005). Major expansion and diversification c. 180ya (Wirth et al. 2008). Infects c. one third(!) of world population today, mostly asymptomatically; possibly supplied brain nutrients for early hominids and/or provided resistance to other pathogens, historically and presently; low latency between asymptomatic infection and pathogenic activation, c. decades, is thought to be an ancient adaptation to avoid extinction in small populations (Brites and Gagneux 2015). Once thought to be a zoonosis derived from cattle, early genetic sequencing revealed transmission happened in the opposite direction (Garnier et al. 2003).
Syphilis, Yaws etc.	The *Treponema* strains that cause syphilis, bejel, yaws and pinta are so closely related that the biological basis for their distinction has not yet been discovered or is actually challenged (Marks et al. 2014; Giacani and Lukeheart 2014). Harper et al. (2011) review compelling evidence that venereal syphilis arrived in Europe from the New World; if so it represents the only pathogen to have done so in historical times; skeletal evidence in the New World dates to 7kya. Thereafter syphilis rapidly spread throughout Asia with the Portuguese, reaching most major regions in as little as 15 years; yaws picked up in Africa made the same journeys (Boomgaard 2007). The various strains might be of human or primate origin: benign Treponemas have been found in guts of children in rural Africa (De Filippo et al 2010) and in a coprolite sample dating to 1.4kya from northern Mexico (Tito 2012); wild African baboons suffer infection by a strain resembling that which causes yaws in humans although the genetic evidence is not yet sufficient to untangle the relationship, which might be ancient (Harper et al. 2012; Giacani and Lukeheart 2014). Rothschild (2005) argued that yaws infected *Homo erectus* in East Africa c. 1.5mya, and that daughter strains of bejel, pinta and eventually syphilis emerged as *Homo sapiens* spread round the world; the debate has not yet achieved consensus.
Falciparum malaria	The greatest of six malaria plasmodia (a single-celled eukaryote) which infect humans; probably spilled from gorillas deep in prehistory, not chimpanzees which had been considered (Liu et al. 2010; Prugnolle et al. 2011); multiple emigrations from Africa also in prehistory c. 100-40kya (Joy et al. 2003; Tanabe et al. 2010); thrives in transformed ecologies associated with farming and irrigation, i.e. standing water for mosquito breeding, plus livestock hosts, plus greater human densities (McNeill, J.R. 2010), hence burden on humanity increased c. 10kya and left a marker in human genetic changes associated with resistance (Hedrick 2011); Plasmodia genetic tree also branched dramatically c. 6kya (Joy et al. 2003). It is possible our host-pathogen relationship pre-dates *Homo sapiens*, i.e. humans co-evolved with Plasmodium Falciparia (Wolfe et al. 2007), but latest reviews do not consider this; might be true of Plasmodia evolution among other great apes (Tanabe et al. 2010). The plasmodia have had to evolve to evade mosquito as well as mammalian immune systems, demanding adaptability and creating diversity (Cruz 2014).

Plague	Relationships among different strains of *Yersinia*, and plague events, uncertain; phylogenetic tree places the origin in China, from where it spread through Central Asia and in other directions multiple times (Morelli et al. 2010). Oldest skeletal evidence of infection from central Asian steppe, c. 5kya matches genetic divergence estimates of c. 5.8kya (Rasmussen et al. 2015). First major pandemic was 'Justinian Plagues' of 540s C.E. onwards, but might have caused local epidemic as early as 11th century B.C.E. (Kohn 2008); famous for 14th century 'Black Death', but also 1911 global pandemic narrowly averted. Aerosol transmission might be older than rodent-flea transmission, which required more complex adaptations to survive the flea gut (Rasmussen et al. 2015).
Polio	Originated from benign enteroviruses in the human gut; only humans are infected; raises possibility that it could re-emerge if eradicated (Jiang et al. 2007). Pictoral evidence of infection in ancient Egypt c. 3.5-4kya, but not epidemic until c. 19th century (Waldron 2009; Mehndiratta et al. 2014)
Smallpox	Scourge of civilization from earliest times; humanity's biggest viral killer, c. 300m deaths in 20th century alone; variants infect multiple domesticates, ultimate source African gerbils (Esposio et al. 2006). Camelpox is the closest related to humans' *variola virus,* although the direction of spillover is unknown; cowpox is possibly ancestral to both (Gubser et al. 2004); more recent genetic analysis confirms this result, and places the emergence in East Africa c. 4-3kya; naked sole gerbils (grassland creature) -> camels -> humans in the Horn of Africa is most likely route after camels were introduced there c. 4kya (these animals had not previously made contact); climate change and ecological disruption associated with the Santorini eruption c. 1650-1540 B.C.E. might have been a factor (Babkin and Babkina 2015); from there spread to Egypt, Middle East, India and beyond; like measles requires c. 200-300k host population size to maintain chains of infection due to lifetime acquired immunity. There are c. 10 species in the *Orthopoxvirus* genus; 3 are native to North America (Emerson et al. 2009).
Cholera	Written evidence for cholera-like symptoms dates from 5th century B.C.E. India (Harris et al. 2012); first pandemic outside India from early 19th century; outbreaks in London c. 1850, investigated by John Snow, lead to milestones in the histories of data-driven epidemiology and of public health authorities (Hempel 2013). Present in aquatic environments, associated with certain types of plankton; only a small subset of the genus infects humans; also infects marine animals; does not grow well in stagnant conditions e.g. ponds, which might have provided the selective pressure to adapt to human faecal-oral transmission (Colwell 1996, Harris et al. 2012); certain fish and shellfish, and copepod plankton, might be important as vectors of human infection as well as reservoirs (Amalgro-Moreno and Taylor, 2015).
Influenza A	Earliest written evidence c. 400 B.C.E (Potter 2001); consistent with genetic evidence (Suzuki 2001). Birds are the natural reservoir; multiple ancient and recent spillover events, typically via poultry or pigs, inc. 2006 'bird flu' and 2009 'swine flu' minor pandemics (Quammenn 2012); causes significant economic damage to poultry stocks. Unstable RNA virus which can evolve rapidly and can recombine genetic elements from strains that infect different species; constitutes one of the greatest risks to humanity in the foreseeable future (Smil 2008).

Typhoid	Leading suspect in the Plague of Athens 430 B.C.E. (Papagrigorakis 2006). Strictly infects only humans; has been demonstrated to infect chimpanzees asymptomatically in lab conditions but origin unknown (Galan 2016); relative of the bacterium that causes modern 'salmonella' food poisoning. Divergence of the strain that causes typhoid in humans is c.150-15kya (Crump et al. 2010); date of emergence as human disease is unknown but estimated at 15% as long ago a initial divergence, following genetic recombination with paratyphoid A strain, and restriction to humans at this time (Holt et al., 2009), which suggests it is a post-civilization disease. Individuals can remain infectious after recovery from the disease, acting as long-term reservoirs (Yap et al. 2014). Origins might have been from gut commensals or the general environment; many animals are infected by varieties of salmonella bacteria, but we have not found any suggestion of zoonosis. Multi-drug resistant strains of *salmonella typhi* are emerging today, often by horizontal gene transfer (Yap et al. 2014).
Yellow fever	Yellow Fever spilled over in Africa c. 1.5kya according to genetic analysis of the flavivirus family tree (Bryant et al. 2007, Hanley et al. 2014); the primate genus *Cerocepitethicus*(guenon) is the most important host reservoir (Hanley et al. 2014). Genetic analysis of New World strains confirms their divergence c. 300-400 years ago (Bryant et al. 2007), consistent with documentary evidence of epidemics since the 1640s (McNeill, J.R., 2010). Yellow Fever did not migrate eastwards into Asia, despite the East African slave trade into the Arab world, for reasons unknown (Cook and Holmes 2006).
Measles	Molecular evidence points to relatively recent spillover from the *rinderpest* virus in cattle, c. 11th-12th centuries C.E. (Furuse et al. 2010); bats are ancient reservoir; related to Hendra and Nipah (Drexler et al. 2015). The spillover date or place for rinderpest are unknown; Chamberlain et al. (1993) suggested then *current* Middle Eastern strains originated in India; rinderpest has subsequently been eradicated. Written evidence for measles hints at earlier strains than the genetic dates suggest, or something causing similar symptoms, might have spilled over previously and caused epidemic events; latest date would be c. 9th century C.E., dated by accurate contemporary observations made by the Arabic medical scientist Rhazes, or Al-Razi (Furuse 2010). Wirtheim and Pond (2011) challenge the genetic dating methods, offer an alternative analysis which yields a date of c. 900 C.E., but argue this also might underestimate how old is measles' emergence. Al Rhazi's meticulous clinical observations probably remain our best guide to a date so far.
Typhus	Oldest definitive description from Salerno, Italy, 1083 C.E. (Szybalski 1999); one of several) pathogen(s) proposed for Athenian Plague 430 B.C.E. but appears unlikely (see Typhoid Fever entry); louse-borne epidemics have been a major scourge where people have been housed in close proximity with poor sanitation, e.g. armies and Atlantic slave ships (Raoult et al. 2004). Closely related to *Rickettsia typhi* which infects mice, but geographical origins are hard to determine (Wolfe et al. 2007); mice which host vector fleas carrying *Rickettsia prowazekii* also suffer high pathogenicity, suggesting this pathway is of recent origin (Conlon 2012). Rickettsia bacteria cause intra-cellular infection and rely on host genomes for certain vital protein manufacture in a manner 'functionally equivalent' to how certain viruses work (Ryan 2009). Curiously, *Rickettsia* are the closest-related bacteria to mitochondria, the power units of eukaryotic cells, having diverged c. 1.5Gya (Andersson et al. 1998).

Common Colds	"The" is a misnomer that masks c. 200 different viral agents from several major virus families, causing similar symptoms or infecting asymptomatically. Coronaviruses (bats and birds) and HMPV (birds) have animal reservoir origins; rhinoviruses relate to enteroviruses of the human gut. Dating of the rhinoviruses of the cold by genetic sequencing is not possible due to their rapid mutation rate; their evolution into aerosol-borne agents infecting the lungs might have occurred deep in prehistory, or have been a phenomenon of civilization (Adler 2013). Woo et al. (2012) date the common ancestor of coronaviruses to 10kya, with several major families that infect multiple animals branching at 5-3kya; however Wertheim et al. (2013) challenge the dating method and suggest an ancient origin c. 300mya, consistent with the evolutionary divergence of the ancestors of the original host species; see the entry on SARS for a recent zoonotic spillover. HMPV jumped as recently as c. 200ya, from birds (de Graaf et al. 2008).
AIDS	Human immuno-deficiency virus (HIV) evolved from a simian equivalent (SIV) that infects chimpanzees with low virulence, with at least 12 spillover events in central Africa; one, dated to 1908, is the ancestor most infections today, split into multiple sub-strains (Quammen 2012). See main text for a description of the spillover event and eventual emergence.
Zika	Causes mild fever or is asymptomatic in adults; infection during pregnancy causes foetal deformity including microcephaly. First isolated in a Rhesus macaque in 1947, but infects many mammals and vectors in West Africa (Vorou 2016); first human victims diagnosed 1952; spread gradually throughout world tropics thereafter; made recent news headlines due to epidemic 2015-16 in Brazil and spreading further afield.
Ebola	Can infect a number of animals via fruit half-eaten by bats; fruit bats not confirmed but most likely reservoir; major epidemic 2013-16 made global headlines; epidemic has also devastated great ape populations (Quammen 2012); see main text for more detail.
Nipah	First outbreak in 1999 in Malaysia, well-documented emergence allows us to observe the gradual emergence first in pigs, as they came more and more into contact with fruit bats, and then pigs' role as a conduit to humans (Pulliam et al. 2012; Engering et al. 2013); see main text for more detail.
SARS	Respiratory disease highly contagious originated from wildlife food markets of south China c. 2003; ultimately from bats; spread as far as Toronto (Quammen 2012); see main text for more detail. Relative of the coronaviruses which cause the common cold (as is MERS, derived from camels, not listed here).

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“Why is there an I.T. guy at a big history conference?”

By Heathe Kyle Yeakley

I joined the IBHA in February, 2012 and attended the Grand Rapids conference a few months later. I wasn't sure *if* or *how* I would fit in with the big history community. Unlike most IBHA members, I have absolutely zero affiliation with academia. At the time of the Grand Rapids conference, I did not even possess a bachelor's degree. I am a Linux systems administrator by trade, and in 2012 my job consisted of working on a team of people who managed a group of servers that calculated payroll for the entire United States Department of Transportation. (That description is 1,000 times more glamorous than the job. Trust me.)

My profession raised many an eyebrow at the Grand Rapids conference. A humourous pattern developed as I walked around meeting people.

Me: “Hi! My name is Heathe!”
Them: “Hello, Heathe! I'm [name]!”
Me: “Hello, [name]! Tell me, what do you *do*?” (Note the wording. I am making *zero* assumptions about what this person does professionally.)
At this point, I often hear -
Them: “Well, I *teach* [subject] at [some university].” or “I *study* [subject] at [some university].”
- which is usually followed by -
Them: “So, where do *you* teach?” (It's assumed I am an educator somewhere.)
Me: “*Teach?* Oh, I don't teach anywhere. I'm an I.T. guy.”

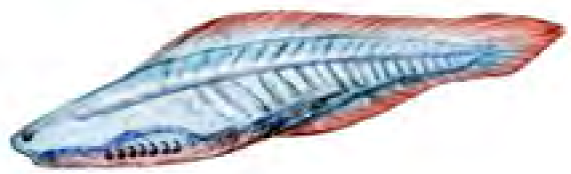
My response has left more than one person utterly perplexed. I'm fairly confident I would have elicited fewer odd looks had I introduced myself as a professional crocodile snuggler.

What's even more amusing, is that very few people asked the logical follow up question:

“Why is there an I.T. guy at a history conference?”

I think that's a fair question, and the answer led to the creation of our brand new website.

So, why *is* there an I.T. guy in the IBHA? How did my brain start out at “Linux” and arrive at the intersection of Complexity Blvd and Threshold Lane?



#1) I'm an amaeteur paleontologist. My mind has no trouble thinking about time at different scales or with "zooming in and out" to consider historical events from different angles. Big history strongly resonates with my inner *Haikouichthys ercaicunensis*.

#2) As a Linux administrator, I work with information for a living. I find the act of organizing and managing information to be a challenging and rewarding experience. Can you think of a field, profession or discipline that has *more* information to work with than big history?

As I drove home after the Grand Rapids conference, I contemplated everything I experienced over the last few days. Where did I fit into this? I am not a professional scholar, nor am I attached to any university or institute. How could I contribute?

The obvious answer was: something involving technology. From there, it was a small leap to "something with the website." That is where things began to rapidly grow complicated.

"I don't know web design, but I could pick up a book."

"If I'm going to learn web *design*, I'll need to learn web *administration* as well."

"What exactly would I do with the site? Am I just going to make it look a little nicer? Or am I going to overhaul the entire site and build something magnificent from the ground up?"

"You know what would be awesome? A big history podcast…"

"Or how about a wiki? Man, that would be amazing. A big history wiki written *by* big historians. That would be the ultimate example of collective learning…"

By the time I arrived back in Oklahoma, "make the website look 5% better" had evolved into "completely restructure the IBHA's digital existence."

That's not exactly something I can knock out in a Saturday afternoon.

Furthermore, several of my ideas were interdependent. I found it difficult to find a clear starting place.

I decided to start with the name. Why is our website ibha***net***.org? I find that name confusing. The last characters of a domain name are what is known as the "top level domain" (TLD). You're familiar with TLD's like .com, .net, .org, .mil. The IBHA's domain name has *two* TLD's used back-to-back: *net*.org. Furthermore, we aren't the "International Big History Association *Network*." To me, the logical choice would either be ibha.org, or bighistory.org. Out of curiosity, I decided to lookup both addresses.

ibha.org turned out to be the home of the Iowa Behavioral Health Association. That isn't too odd. The letters "ibha" could represent a number of different organizations.

Bighistory.org, on the other hand, had a much more interesting story.

My inquiry led me to a married couple in Mankato, Minnesota named Leigh and Gretta. I contacted Leigh a week after arriving home from Michigan and explained that I am a member of an association of big historians, and that I was curious if he would be interested in donating or selling the domain name bighistory.org? Leigh explained to me that Dr. Christian visited Mankato several years ago and shared the big history narrative with him and Gretta at their home. Dr. Christian's work fascinated Gretta and she asked Leigh to register bighistory.org so that the name couldn't be hijacked by DNS squatters (which, sadly, was a very legitimate concern in the late 1990's.) Leigh obliged and the two of them had been renewing the domain name every year for over a decade. Leigh also told me that, a year prior to my calling him, Bill Gates' people had called him asking if they could buy bighistory.org for use with the Big History Project. They even offered $1,000 for the name, and Gretta had said 'no'.

I assured Leigh that the IBHA is a scholarly association dedicated to the advancement of big history, and that we would put the domain name to good use. Leigh and Gretta considered my request for a few days and informed me that, while they weren't interested in parting with the domain, they would be happy to setup a DNS redirect so that anyone who typed bighistory.org into a web browser would be redirected to ibhanet.org.

That's not *quite* the outcome I hoped for, but it was a start.

My next step was to start learning web design in my spare time. I purchased a couple of online courses and a book or two and started messing around with HTML in my spare time.

2013 arrived.

On May 20th, 2013, Oklahoma experienced another one of its world famous tornadoes. This one flattened my hometown of Moore, taking out my sister's house along with hundreds of other homes. My sister, her husband and her dogs were fine, but their home and most of their belongings were lost.

Around the same time, I decided that I had been putting off finishing my bachelor's degree for too long. I enrolled in a program for working adults and began working on my degree. Between the tornado and my school schedule, re-doing the IBHA website fell off my "To Do" list.

About a year ago, I began receiving email correspondence from Dr. Lowell Gustafson asking me about online journal software. The IBHA executive committee wanted to launch a journal of big history and were considering the idea of doing so digitally. Lowell wanted to know if our existing Wild Apricot site could run the journal software, or if we would have to host the journal elsewhere.

As I began reading through the journal software documentation, I started thinking about all of those ideas I had on the drive home after the Grand Rapids conference. That was 4 years ago. I really needed to sit down and draft up a plan of action on how to enhance the IBHA's online presence.

About a month after Lowell and I began corresponding on journal software, I found myself in the captivating city of Amsterdam (my first venture onto European soil, I might add), enjoying yet another week in the presence of big historians. I discussed some of my website ideas with Lowell, Craig and Pamela Benjamin, Donna Tew, Barry Rodrigue, and a few others. All of my ideas were met with approval and enthusiasm. I couldn't wait to return home and begin working.

Upon arriving home from Amsterdam, I set to work. After researching and shopping for hosting providers, I decided to go with BlueHost. I purchased a basic hosting package, installed WordPress and began playing around with how to integrate Wild Apricot into an existing WordPress site.

As Christmas approached, I had a very basic IBHA website up and running. it occurred to me that this new website possessed a new IP address. Once I finished migrating all the data from Wild Apricot to WordPress, I would need to contact Leigh in Minnesota and ask if he could change his DNS redirect to point bighistory.org to the new IBHA website.

As I began typing up the e-mail, I thought "I wonder if Leigh would reconsider my request about donating/selling bighistory.org to the IBHA? I would *really* like to acquire that address for the new site I'm building…"

I contacted Leigh and explained how I was building a new online home for the IBHA and if there was any chance we could revisit our conversation from 2012 about the IBHA acquiring the URL bighistory.org. Leigh and I spent the holiday season discussing the acquisition via e-mail. In January, Leigh agreed to donate the domain to the IBHA.

Over the next few months, I worked with freelancers in my spare time to help me stand up and deploy the new site. We had a solid working site by the end of May. Now I needed to test the site to ensure that it worked.

I asked the IBHA executive committee to log in, use the site, and inform me of any issues they encountered. I spent most of June and July going over the feedback I received to put the finishing touches on our new home. I am proud to say that I believe the site is complete and ready for use.

Feel free to begin using the site now.

https://bighistory.org

I will officially "throw the switch" on August 1st, 2017 and move all of our DNS settings to point to the new website.

If you encounter any issues using the new site, please feel free to send an e-mail to support@bighistory.org.

If you want to send *me* an e-mail, feel free to drop me a line at hkyeakley@bighistory.org.

Enjoy the site!

- Heathe Kyle Yeakley

IBHA conference
July 26 - 29, 2018

Please plan on participating in the 2018 IBHA conference from July 26 - 29 at Villanova University, near Philadelphia, Pennsylvania, USA. Here are directions to Villanova, which is a half hour train ride from Philadelphia on the "Main Line." Take a virtual tour of Villanova here. Panels and plenary sessions will be in the Connelly Center. You may reserve an attractive room on west campus or stay at nearby hotels.

Before or after the conference, you will enjoy the Philadelphia area. Independance Hall is the birthplace of America; it is where the Declaration of Independence and later the US Constitution were signed.

Great museums include the Philadelphia Museum of Art, The Barnes Foundation, Rodin Museum, The Academy of Natural Sciences, and the Museum of Archaeology and Anthropology. The Liberty Bell has inspired many in the struggle for freedom. Among Eastern State Penitentiary's celebrated prisoners were Al Capone. A few ideas for restaurants are here, another one is here, and here.

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give us information to plan for housing
accommodations

Big History Comes to North Carolina

By Lucy Laffitte
M.Ed, Ph.D.

Dr. David Christian received an honorary degree acknowledging his pioneering work in the field of Big History from North Carolina State University.

On Saturday, May 13, 2017, Dr. David Christian received an honorary degree acknowledging his pioneering work in the field of Big History from North Carolina State University.

Congratulations Dr. Christian!

Why, you might ask, was North Carolina State University, a Research I University most noted for science and engineering, the first to recognize David and Big History? Let's look at the timeline, key ingredients, and the Goldilocks conditions that led to David donning a hood *honaria causa* in the foothills of North Carolina in May.

The timeline spans ten years. "Key ingredients" included a history professor named David Gilmartin, an Australian provost, and IBHA founders Cynthia Brown and Craig Benjamin. The Goldilocks conditions were, of course, the steady stream of articles, chapters, books, presentations, interviews, encyclopedia entries, televised courses and the TED Talk David Christian pumped into the noosphere.

The thing about Goldilocks conditions is that you can't predict the extent of what is going to emerge. It shouldn't be surprising, then, to hear that one round trip for an honorary degree turned into a whirlwind of 17 events in eight days across North Carolina for David *and* his wife Chardi. By the time they boarded the plane home, the Christians had engaged with representatives from three college campuses, two school districts, three museums, a state agency, a federal agency, and several businesses. They'd also been able to get away both at the coast and at the quaint town of Chapel Hill where they had lived while at the National Humanities Center ten years ago.

David Christian and Director the Museum of Natural Science Emlyn Koster

So, what was the impact of this whirlwind of activity? At the Chancellor's dinner, the night before the commencement ceremony, David stood up and thanked N.C. State University for the courage to acknowledge the emerging field of Big History. Over the course of the week, approximately 175 people got to hear David speak. The question and answer sessions were filled with people from a variety of disciplines asking for more ways to engage with Big History. There was a lovely testimonial to the value of the Big History course in the Honors College at North Carolina State University. While meeting with a group of faculty in the history department, one of the students from this course was in attendance. When asked what she thought of Big History she said, "You know, I've been getting A's in high school and college, taking all the AP courses and stuff but I always felt kind of lost. After this course, I know where I fit in, in the scheme of things."

Spirited debates erupted twice during the week. Following the history department event, a small group went to a coffee shop to further discuss Big History. This was the first opportunity that David Gilmartin and David Christian were able to converse substantively. They dug right in and quickly found points of disagreement. The conversation was energetic. And loud. They debated the veracity, ethics, and implications of the rising narrative arc of increasing complexity in Big History. The second contentious discussion involved Pierre Comizzoli, the Senior Program Director in Science of the Smithsonian Institution. As a conservation biologist, he stood up at the elegant dinner presentation and questioned the notion that the sixth extinction of the anthropocene could be construed as a "natural" emergence of the universe. Resolution in both cases was not achieved but the caliber of the debate was riveting and relevant.

In a luncheon roundtable discussion called *Big History: A Curriculum for the Anthropocene*, educators from both formal and informal settings explored the way Big History could be incorporated into the curricula. Some potential next steps were discussed that may or may not come to fruition. An administrator at the NC Department of Natural and Cultural Resources is now mulling over using Big History as a hook for increasing tourism. This would mean that families, after a visit to a planetarium, mountain waterfall, zoo, or battlefield, might earn credits to a certificate in the *Big History of North Carolina*. Another possibility under consideration is at the prestigious state-funded School of Science and Math. Two administrators are going to enroll in the *Big History Project* online to consider using Big History as an organizing principle for a second campus opening in 2020.

At the moment, there is only one teacher in the entire state using the *Big History Project* curriculum. Ms. Collyn Gaffney teaches at Brunswick County Academy in Bolivia, NC, population 143. Her class is made up of the students who failed 8th grade and are seeking a second shot at high school. David and Chardi had visited this classroom earlier in the week. The Christians observed an astounding and

Dinner Event

empowering classroom ecosystem where the learning of Big History is bolstered by the BHP online curriculum but directed by the students' questions. Gaffney talks the talk with a depth of experience in walking the walk. She uses Big History to transform students' lives.

Partial List of Participants in Big History Events in North Carolina.

Chancellor of North Carolina State University	Chancellor of the North Carolina School of Science & Math
NCSU Dean of the College of Natural Resources	NCSU Dean of the College of Humanities & Social Science
Director of the NC Museum of Natural Sciences	Senior Program Director in Science, Smithsonian Institution
Deputy Director of the NC Division of Natural and Cultural Resources	Director of the North Carolina Emerging Issues Forum
Faculty from NCSU in Engineering, Education	Faculty from Duke University

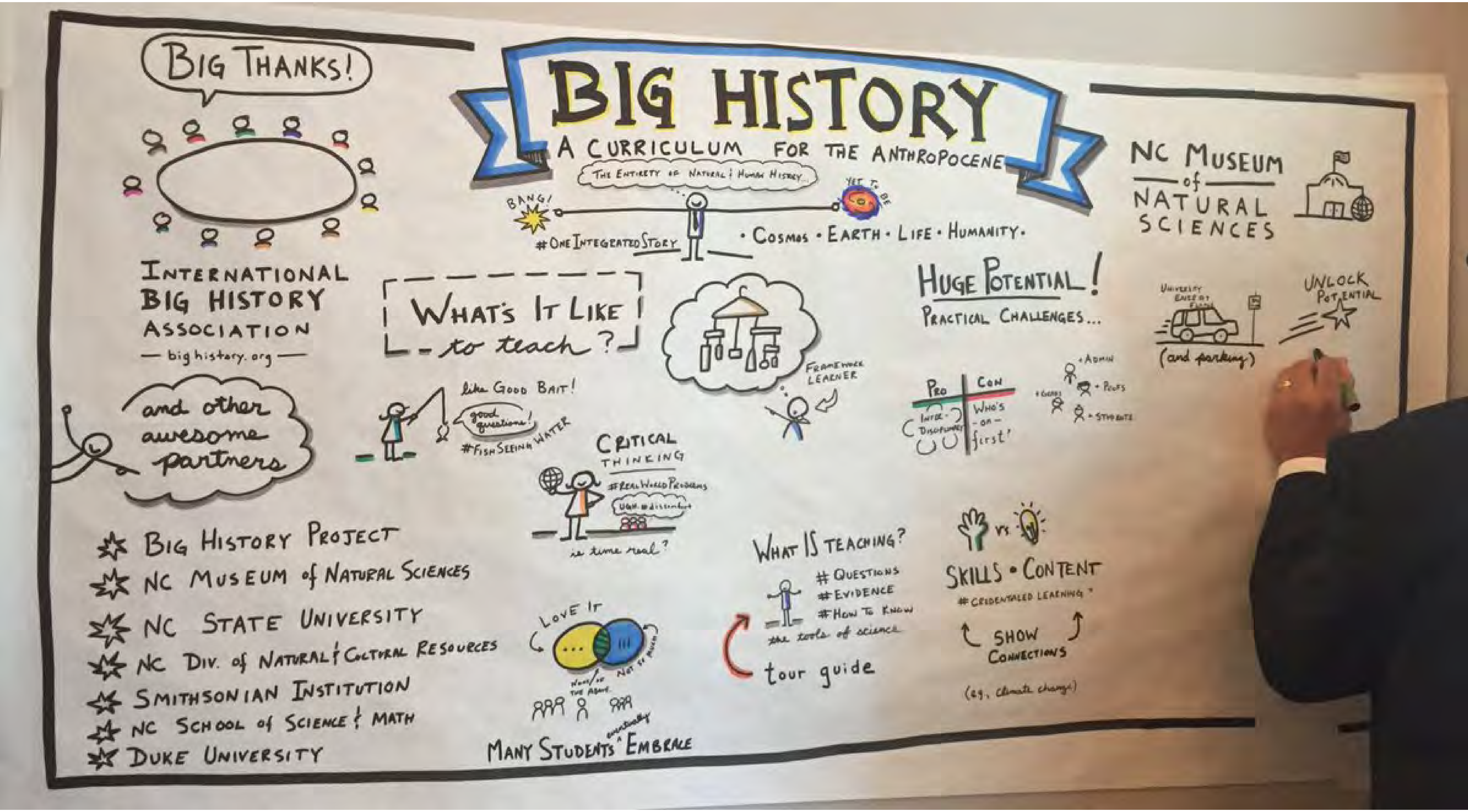
Of all of the people participating in Big History in North Carolina, the designation of the MOST enthusiastic and MOST generous goes to the Director of the North Carolina Museum of Natural Science, Emlyn Koster. In January, when I started planning how to make the most of David's imminent trip to Raleigh, I brought it to the attention of Emlyn after an evening event at the museum. He lunged at the opportunity to engage with David. In short order, Emlyn made it possible for Chardi to come, extended their housing, offered to host an elegant dinner and a working lunch, and made arrangements with the upper echelons of the Smithsonian Institution to attend these events. When Emlyn had the chance to finally meet David, the grin was ear to ear. By the time the week was over, seated

Discussants at Curriculum for the Anthropocene Roundtable Luncheon

around a fine dinner, cocktails in hand, the synergy between Emlyn, Big History, and David was palpable. Emlyn asked David to co-author a paper with him for the International Council of Museums Committee for Museums and Collections of Natural History Conference in 2018 on *Big History, Museums, and the Anthropocene.* "Big History," Emlyn explained, "is the curriculum for the Anthropocene and museums are the place that will connect the two." Emlyn's embrace of Big History will give the IBHA a new ally and entre into the realm of natural history museums, a logical and complimentary partner.

I am awash in gratitude to the many people who made these eight days in May such a success. Thank you David Gilmartin, Cynthia Brown, Craig Benjamin, Emlyn Koster, Lowell Gufstafson, and the IBHA for contributing funds for the luncheon. And Thank you, Thank you, David & Chardi, for spending such a huge amount time and energy sprinkling the seeds of Big History across so much of North Carolina. I intend to water, weed, and nourish as many of them as possible.

David & Chari Christian, Carol O'Donnell , Maryse & Emlyn Koster, and Pierre Comizzoli (Carol and Pierre travelled from the Smithsonian Institution).



White Board Academy Artist Captioned the Major Points at the Round Table Discussion.

New and Returning

IBHA Members

One of the key purposes of the IBHA is for those of us who are interested in Big History to have a place to associate. It is a place to learn of other members' Big History activities and thoughts. So we are delighted to welcome new members to the IBHA – and by the vote of confidence and recognition of the value of our association by those who have renewed their membership. It is a pleasure to have each of you with us.

David Blanks
David Christian
Wendy Curtis
Philip Day
Imogene Drummond
David Fisher
Elizabeth Fraser
Katie Fritz
Olga Garcia-Moreno
Gabriel Gromadzyn
Lowell Gustafson
Tony Harper
Jack Healy
Jess Hollenback
Philip Hughes
Pieter Lagerwaard
Jeremy Lent
Penelope Markle
Arie Mijnlieff
Chris Oddy
Gordon Olson
Jack Pearce
Peter Rathmann
Barry Rodrigue
Patrizio Sartini
Birger Schmitz
Evan Penn Serio
Brian Spooner
Tracy Sullivan
Meg Veilleux
Dana Visalli
Jacob Wamberg
Jos Werkhoven
David White
Barbara Winkler

International Big History Association

An example of the value of an ongoing association of big historians is the discussion that has been going on in our website blog. Please consider either joining in the discussions, or start a new topic of your own. Or ask a question and see what answers to it you elicit. You may later wish to develop this into a paper or panel proposal for the 2018 IBHA conference, where the discussion can continue in person. This may lead to a submission of an article to *Origins* or the *Journal of Big History*, which is made available to IBHA members. Join in the process of collective learning!

IBHA members are from:

Argentina	Ecuador	Nicaragua
Australia	France	Norway
Austria	Germany	Peru
Bahrain	Hong Kong	Russia
Belgium	India	Serbia
Brazil	Ireland	South Korea
Canada	Italy	Spain
Chile	Japan	Sweden
China	Korea	United Kingdom
Denmark	Netherlands	United States

Big History Talk Concert in South Korea

by ***Seohyung KIM***
(Chief Director,
CHO Big History Academy)

Big history is a new methodology to connect different disciplines within the larger frame based on scientific evidences and knowledge to understand the world better. Since the late 1990s, South Korea has emphasized convergence education, which tries to connect natural sciences and humanities together and find interconnections. In this sense, some Korean scholars, especially scientists thought that big history, which begins from the Big Bang, the origin of the Universe to the Present, and the future can be one of the powerful models for convergence education.

South Korea began to teach big history from 2009. The Institute of World and Global History at Ewha Womans University invited Professor David Christian for 5 years to teach big history and discuss academic topics together with the late Professor Ji-Hyung CHO. After the sudden death of Professor Ji-Hyung CHO, some scientists and I established CHO Big History Academy in 2015 to develop big history education and science culture based on

big history. The Big History Academy held a big history workshop each year for academic professors, teachers and the general public. This provided opportunities to discuss origin stories and changes of world view beyond barriers of disciplines to.

Last June, Big History Academy held a “Big History Talk Concert.” We wanted to have an interesting chance to discuss big history from different academic backgrounds and explore the meaning and importance of big history. We thought of the event as a concert. For our big history concert, I invited Professor David Christian and Professor Lowell Gustafson to each talk about big history. Also, we organized for the participation of South Korean scientists. One is astronomer, the other a neuro-scientist. The third one Korean speaker is a futurist and the fourth is high school science teacher. We planned to talk about big history from the perspective of different scientific fields and according to chronology, such as from the past, to the present and to the future.

In the first part, Professor David Christian explained big history and the reason why we need that kind of larger pattern of interdisciplinary approaches in the 21st world. He showed the famous painting of Van Gogh, which included origin stories in the world. With his talk, we can understand the necessity of understanding origins stories of everything: the Universe, the Sun and the Earth, the life and human beings. We can imagine how these different origin stories could be connected within the big history storytelling. And we fully understand why we need big history perspective for better world.

Professor Lowell Gustafson talked about emergent complexity. He began his talk about Korean history of Paleolithic Era and how people have long shared lots of questions about their origins, such as “Where did we come from?” or “How we can think about the future?” In recent centuries, many people have devoted their professional lives to understanding how light, rocks, bones, and blood tell their stories about our origins. From the big bang to matters and elements, solar system and the Earth, LUCA and human beings, he talked about emergent complexities and showed how big history is a new story to support emerging relationships among peoples.

In the second part, Korean scientists participated in the big history talk concert. At first, Kangwhan Lee, Director of Seodaemun Natural History Museum talked about the past. He is astronomer, so he told long history of the universe and why we need to understand the long journey from the universe to the present. Next was Professor Jaeseung Jung, who works at KAIST, who talked about the present. He is neuro-scientist and has interest in explaining the current situation in its relationship with the brain. (Currently, brain engineering is one of the hot topics in Korean society.) He presented the big history and evolution of the brain and its functions. The third participant was Professor Ji-hoon Jung of Kyunghee Cyber University. He is a medical doctor and with an interest in information and the future. He emphasized the future as an extension of the present and the entire past. He argued that this is the reason why we need to understand the past and the present as we prepare for a better and sustainable future. The concluding participant was Hyogun Lee, ascience teacher at Hana Academy. Hana Academy

the first high school that taught big history as the regular course in South Korea. He talked about the importance of big history education, which can show not only large maps for students to understand their interests, but to recognize their current situation, and to develop their futures based on interdisciplinary studies.

After the talks, all the participants had time to discuss questions from the audience. Discussion among humanists and scientists is rare in South Korea, because each scholar from different fields seldom have the chance to meet other experts. As a Korean historian specializing in American studies, I had little chance in my own educational background to meet and talk with scientists, but we can do that with big history. In this sense, Big History Talk Concert has two important aspects. One is to meet people from different fields within big history, which permits the real convergence between the natural sciences and humanities. The second is to free academics from exclusive reliance on lectures, in which information is delivered unilaterally. In the talk concert, we exchange thoughts and developed the interconnections between different disciplines within big history. The Big History Talk Concert is the first trial to embrace the natural sciences and humanities in South Korea. As the Chief Director of Big History Academy, I look forward to more opportunities to discuss big history in Korean society.

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IBHA Board of Directors Elections

Background

The members of the IBHA Board of Directors hold staggered three year terms. Each year, a few seats become open. Since the IBHA was founded, there have been a number of Board members who have cycled off the Board, a number of new people who have joined it, and a number who have stayed on. This year, four seats became open and need to be filled. An on-line ballot for the elections was sent to IBHA members on July 15; the election will remain open until August 15, 2017. These four Board members' terms will run from August 15, 2017 through the beginning of the board meeting in 2020. The new board members will be announced immediately after the election is completed.

In the interest of fostering continuity, change, stability, and inclusivity, the IBHA selects Board candidates in two ways:

(1) IBHA members identify names
(2) and the existing Board proposes a list of names.

Between April and June 1, 2017, IBHA members could log on to the IBHA website and post the names of any members they recommended for Board membership. Nominees who were endorsed by at least 10% of IBHA membership before June 15, 2017 would become candidates. By June 15, the IBHA Board also discussed and decided on its list of candidates.

Two Sections of the Ballot

Section 1

The first section of the ballot will be for all IBHA members to vote on a board recommendation for amending the IBHA by-laws permitting the addition of a special seat to the board. As mentioned above, there are now four open seats, each for a term of three years. If at least two-thirds of those IBHA members voting approve of the following board recommendation, a fifth special seat will also be open, with a term of two years.

The board recommends that paragraph 3.1 of the current IBHA by-laws be amended to include ***the italicized bold text*** below

> 3.1 Board of Directors. The business and affairs of the Corporation shall be managed exclusively by a Board of Directors. The Board of Directors shall consist of not less than three (3) nor more than twelve (12) persons, all but one of whom shall be elected by the members. The twelfth director shall be the immediate past president of the Corporation, who, subject to earlier resignation or removal, shall serve as director for one (1) year following the election of his or her successor as president of the Corporation. ***In the event a past-president does not take the twelfth board seat, that seat will be put up for election to the IBHA membership to be occupied by all the rules of the IBHA until a new past-president takes that seat, or 3 years since election to that seat have elapsed, whichever is sooner.*** . . .

At least two-thirds of members who vote in the election need to approve of this for it to be added to the by-laws and to open a fifth, special seat in the election.

Section 2

The second section on the ballot will be in regards to choosing who will fill the open board seats. The four candidates receiving the most votes will fill the four regular seats. If the board recommendation is approved by the IBHA membership, the person with the fifth highest number of votes will fill the special seat.

It is a strength of the IBHA that there are many members who are highly capable of serving on the board, and this list is but a portion of them. It is also important for the health of the association that we choose among a variety of candidates. All these highly capable candidates, win or lose this particular election, have contributed significantly to big history and continue to do so, in part by having agreed to be included in this slate. We are all indebted to our candidates for their contributions to big history and their willingness to place their name on this slate.

As a result of this process for selecting nominees for the board, the slate of candidates for the IBHA board seats in 2017 is:

Javier Collado Ruano (Ecuador)
Seohyung Kim (South Korea)
J Daniel May (USA)
John Mears (USA)
Nobuo Tsujimura (Japan)
Constance van Hall (Netherlands)
Joseph Voros (Australia)
Sun Yue (China)

Brief information about each candidate is below:

Candidates' Statements

Javier Collado Ruano is Titular Professor in the National University of Education (**UNAE**) in Ecuador. He is teacher on Global Citizenship Education, Sustainability, Philosophy of Education, Big History, and International Relations. He holds a PhD in Dissemination of Knowledge by the Federal University of Bahia (Brazil) and also a PhD in Philosophy by the University of Salamanca (Spain). Master Degree in Sociology of Education by the University of Seville (Spain) and Graduation in History by the University of Valencia (Spain) with specialization in International Relations and Archeology by the University of Palermo (Italy). He is founder and Director at **Global Education Magazine** (supported by UNESCO and UNHCR) and President at **Education for Life NGO**. He is also Academic Member of the **Big History Institute** (Australia), Academic Member at **CIRET** and **FLACSO**, Member at **World Biomimetic Foundation** (Spain), Member of the editorial board at the Journal of **International Society of Philosophy and Cosmology** (Ukraine), Advisory Board Member at **Shreeranya Renewable India**, Chief Advisor and Conferment of Fellowship Awards at **PAN African Institute for Entrepreneurship and Community Development** (Nigeria), and Education Advisor at **Human Dignity and Humiliation Studies** (USA). With one book and more than 25 published papers, his research interests are focused on Transdisciplinary, Biomimicry, Sustainable Development, Global Citizenship, E-learning, Cultural Anthropology, Culture of Peace, Spirituality, Emotional Intelligence, Sociology, Democracy and Governability, Poverty Eradication, Human Rights, Philosophy, Epistemology, Arts, Globalization, Co-evolution, Big History, Complexity, and Life. He won the 1st International Prize on Science and Spirituality Research 2016 by the **Columbia Foundation** (Buenos Aires, Argentina), and also the 2016 Extraordinary Prize of Doctorate in Philosophy by the **University of Salamanca** (Spain).
More information available in: www.javiercolladoruano.com

His vision for the IBHA seeks to expand the IBHA to the Latin America region. He writes the first Spanish PhD theses on Big History. With experience as professor in different universities of Peru, Brazil, and Ecuador, he wants to spread IBHA for citizenship who speaks Spanish and Portuguese. How could indigenous worldview enrich the Big History? How to develop a scientific vision of the Big History using an epistemological perspective from the South? He considers that the first phase of consolidation and dissemination of the Big History has already been completed, and now starts a second phase where a huge epistemological diversification is required. Different readings of the Big History will enrich the debates. It is about creating an ecology of knowledge that combines all scientific and non-scientific disciplines, where arts, spirituality (free of dogmas), and ancestral wisdom (medicine, cosmovisions, etc.) are transdisciplinary and integrated through an inter-epistemological dialogue.

Seohyung KIM

I am the first big historian in South Korea and in Asia. Since 2010, I had taught big history at Ewha Womans University for undergraduate students and graduate students and had collaborative works with David Christian. During this period, we made big history curriculum for Korean schools and tried to spread big history as the bridge between the natural sciences and the humanities. Two years ago, Korean scientists and I established Big History Academy and now we are doing many things for big history through Korea. The first thing is to write and translate big history books. I have published three big history books in Korean and two articles within edited books in English. The Second thing is to make big history curriculum in different levels of Korean schools. There are three high schools, which teach big history as the regular course and from this summer, Big History Academy held teachers' workshop to make regular big history course for middle schools.
In addition to these educational program, I am making big history VR for the first time in the world to emphasize big history as the scientific culture. We are going to renew Natural History Museum as big history museum and create many other cultural contents of big history with Korean scientists. This is one of the most important and powerful ways to spread big history as the general educational foundation in the 21st century and I am sure these works will be so interesting agenda not only in Korea, but in other regions in the world. And this kind of activities will be helpful to develop International Big History Association by embracing different levels of big history contents and perspectives of interconnections based on the convergence of the natural sciences and the humanities within the largest and biggest frames in the universe.

J Daniel May

It's an honor to be nominated to serve on the IBHA board. I began teaching Big History at Dominican University of California in 2011, and since 2014 have served as the program director for Dominican University's Big History Program, a required sequence of courses for all first-year students. I'm particularly interested in developing the pedagogy of Big History, both for its own sake, and as a framework for larger curricular design. I regard understanding of our universal history as essential foundational knowledge for any educated person in the 21st century.

I've been teaching a variety of English courses at Dominican University of California since 1996, including Linguistics, Writing, Literature, and English as a Second Language. No matter what subject I've taught, I've always seen the importance in making connections to other topics, bringing in bits of history, archaeology, hard science, and whatever else I thought could put a particular course into a larger context. Big History is as large a context as one could wish for, the ultimate opportunity to connect the dots and see the whole picture. I also have a passion for storytelling in its many forms: folklore, mythology, live theatre, film, literature, and more. Big History is the biggest story we can tell, and presents challenges and choices about how best to tell it, and how best to teach it.

If elected to the IBHA Board, I hope to further the practical pedagogy and applied knowledge of Big History.

John Mears

John Mears received his undergraduate education at the University of Minnesota and his graduate training at the University of Chicago where he specialized in the history of early modern Europe with a particular interest in seventeenth century Austria. While retaining that primary interest throughout a fifty-three year career of research and teaching, his professional concerns gradually broadened, in part because of his avocational interests in astrophysics and anthropology, in part because of the impact that William H. McNeill and Marshall Hodgson had upon him during his years at the University of Chicago. As a result, Professor Mears joined the World History Association in 1984 and served as its president in mid-1990s. By that time, he was becoming interested in a much broader field of scholarly endeavor we now call big history. Having published a range of articles and essays on the subject of Big History, he joined the IBHA at its inception. By that time he had begun working on what has become a two-volume work tentatively entitled To Be Human: A perspective on Our Common History. As a member of the board, he would plan to concentrate on two things: the completion of this project and the development of the IBHA's new Journal of Big History, especially its book review section.

Nobuo Tsujimura

It's my honor to be nominated for this board election. Over a decade, I have played a key role as a hub to promote Big History in Japan. Originally I learned International Relations at Soka University, Tokyo, where historian Osamu Nakanishi taught it as transdisciplinary studies from historical and cosmic viewpoints. Then I met with Big History. Since then, I have spread it, connected with all the big historians in Japan, and bridged them with foreign big historians. I have developed a series of Japanese big history books with the Institute for Global and Cosmic Peace (IGCP) in Yokohama, including An Introduction to Big History (2014); Big History and the 21st Century's International Order (2014); Applying Big History: Nature, War and Peace (2016); and Universal Studies and the Modern World: Becoming Global and Cosmic Humanity (forthcoming). Since last year, I have run the Oberlin Big History Project (OBHP http://obhp.org/) with Hirofumi Katayama and others at J.F. Oberlin University, the greater Tokyo. Also, I designed the IGCP books and the OBHP website. My interests moved from International Relations to wider historical and social theory until a cultural and artistic movement to practice Big History.

If I have a chance to be a board member, I will foster the following two activities. First of all, I want to develop the Big History movements not only as academic and educational ones but also broader cultural and artistic ones. My goal is to make big history as broad and as accessible as possible – to be lived and felt, to make us sense the world and the cosmos vividly, and by doing so, to vitalize our creativity to weave a new worldview together by involving all the people across all the genres. Otherwise, no people except scholars, teachers, and students could join, since most of the common people don't usually read academic writings or attend school. If we really want to spread ideas of Big History and unleash its creativity, we need to make the world full of Big History-like works and experiences through all kinds of expressions and activities: picture books, movies, dramas, paintings, photographs, novels, music, hiking, diving, travels, websites, virtual and augmented realities and so on. I, Katayama and the Oberlin students have already started the projects to make a Big History picture book and animated film, while I and Katayama have been writing a Big History article for a Japanese music magazine. In the future, we will involve more people and by doing do, we will spread Big History more in Japan and beyond. Secondly, I want to make Big History multi-civilizational. One of my interests is Japanese genealogy of Big History. To find and re-evaluate the pioneers and de-facto practitioners of Big History in Japan will diversify the foundations of Big History and make it more universal. At the same time, I plan to start international exchanges between the Oberlin students and foreign students learning Big History so that we can foster new and global identities, values and networks. Through these activities, I will do contribute to the Big History movements as a whole.

Constance van Hall

What a great and exciting honour it is for me to be nominated for the IBHA board! I'm a teacher at a high school in Hilversum, The Netherlands. I studied philosophy and history at the University of Amsterdam, very interested in the history of ideas and the impact of (scientific) thinking on society. After graduating, I really wanted to get students exited for science and critical thinking, so I got my teaching degree and started teaching philosophy at A. Roland Holst College.

When I saw David's TEDtalk about the Big History Project, I was so impressed and immediately started to investigate how to implement this great course at our school, together with my colleague Joris Burmeister. We had all the 'goldilocks conditions' with us: it was possible to implement BHP in an already existing course at our school!

So, we started teaching Big History in 2012. At the time we were the first school in The Netherlands to take part in this incredible journey. And incredible it was, and still is. We soon realised this course is so inspiring and exciting, every high school student should be able to take it. So we started spreading the word - we spoke on lots of conferences, visited schools in the whole of our country (ok not such a huge deal - Holland is very small), even got on radio and tv and got published in the paper and on Vice. Now, in 2017 there are about 35 schools teaching Big History, my book for high school students got published, Joris and I got to meet a lot of big historians and colleague teachers, travelling to Sydney and Seattle… amazing!

So now I'm nominated to be part of the IBHA board, I hope to be of some help with my experiences helping Big History to spread to the next generation: our high school students - the future of our long journey of 13.8 billion years!

Joseph Voros is a professional futurist whose worldview since teenage has been informed by what he has always thought of as a "cosmic-evolutionary" – or what is now also known as a "Big History" – perspective, derived from such early influences as Asimov's *Guide to Science* and Carl Sagan's TV series (and book) *Cosmos*.

For many years this worldview underpinned his research and postgraduate teaching in Futures Studies and Strategic Foresight, leading to a research agenda based on using Big History to think seriously about the contours of the coming global future, and more recently to the establishment of an undergraduate course on *Big History*, which has been running since 2015, as well as a version of this at post-graduate level in the Master of Strategic Foresight at Swinburne in Melbourne, Australia. His recent publications and activity emphasise this use of Big History in order to "profile" the broad outline of what 'Threshold 9' might look like – such as speaking on this topic at the Big History Institute Anthropocene conference in Dec 2015, as well as a new book chapter in the *Handbook of Anticipation* (Springer International) now in press and due out in 2017, which is intended to introduce futurists to the Big History perspective.

He sees his main contribution to the IBHA Board being to help bring a strong "futures" focus to the wider mission of the IBHA; to complement the many different perspectives and areas of specialty and expertise of other members, so that Big History can form a coherent perspective for humankind—to understand our shared cosmic origins, to steward our present technological planetary civilisation, and to navigate and shape our common future with as much wisdom and foresight as we can possibly muster.

University web page:
http://www.swinburne.edu.au/business-law/staff/profile/index.php?id=jvoros

Sun Yue, Capital Normal University, Beijing, PRC

I first became interested in big history around the beginning of the 21st century, receiving my copy of the *Maps of Time* (in Chinese!) in 2007 from David Christian himself while he was visiting CNU for a conference. Before that, I was reading bits here and there online. And you can see, not long after that, I became a long-standing devotee to Big History. I have published a number of papers on big history in high-profile academic journals and media publications in China, putting together China's first collection of big history papers in 2013. In 2014, I was elected into the IBHA Board.

If re-elected, I would work harder to get big history better publicized in China. Fortunately, China's high-profile CITIC Press has agreed to publish (in Chinese) all major big history publications, and I am personally translating Fred Spier's Big History and the Future of Humanity (2nd ed., 2015) as part of this large project.

And I am also enthusiastic in working to get the *Journal of Big History* (JBH) more diversifying in its transdisciplinary approach by inviting scholars from all conceivable scientific and humanities backgrounds to contribute. Since each culture has its own stories to tell about bridging nature (the universe now) and humanity, heavenly love and mutual benefits, why don't we invite them to tell their own stories as well? To be sure, my personal ambition is to amend the "science" of big history with "love" – to make it a big history of love as well!