ADDRESS BY PROFESSOR IAN HODDER
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The directionality of human evolution: an entanglement perspective

Dear President of the Fyssen Foundation, and Members of the Board of Directors and of the Scientific Committee,
Dear Friends and Colleagues,
Ladies, and Gentlemen,

I am extremely grateful for the award of the Fyssen International Prize. In my presentation I would like to talk about my recent work on the entanglements between humans and material things. As an archaeologist I am of course interested in material culture, and in the recent debates about 'materiality' in the social and human sciences. But as a prehistoric archaeologist, I am also interested in the long term and how it is that we have developed as humans into the world we see around us today. In this talk I want to ask the big question of whether we have got to this point as a species because of a directionality in human cultural development.

The evidence for an overall directionality in human development appears clear. In a series of recent publications Ian Morris has very helpfully used a range of measures to document social development in Europe and Asia since the Pleistocene. More recently he has charted the growth of energy capture in the five most intensive agricultural zones from 11,000 BC to 1 CE (Baumard et al 2015; Morris 2010; 2013). In these studies general prosperity or affluence is measured by using the proxy of energy capture, itself measured by variables such as house size, or by population density or the population of the main city. Obviously it is very difficult to measure long-term trends stretching back into deep prehistory with any accuracy, and the charts hide much local variability. Locally through time there is much evidence of 'booms and busts' (Shennan 2013), with the 'boom' areas shifting around through time (see the discussion regarding the shifting focal centers in the European Iron Age in Hodder 2016, 147). In addition many parts of the globe are not accounted for in Morris' charts. In some areas, such as pre-colonial Australia, overall trends may appear difficult to discern. And yet a recent review of the prehistory of Australia (Cane 2013) tells of continual change since the first settling around 74,000 years ago. In particular since 18,000 BP there were new technologies (eg boomerang), more diverse and efficient stone tools, new migrations, new forms of art, increased territoriality linked to increased population, more village formation and more extensive trade. Globally, while there is much evidence of local variation and great difficulty in measurement, there is much evidence for growth in the amount and complexity of human use of material culture.

Another way of exploring this trend is to contrast early human-made things with those produced today. This provides a yet more crude indication, but the contrasts are nevertheless instructive. I have a rather disparate bunch of examples – sickles, cotton, pots and the wheel. Take for example the earliest sickles used to cut grasses (Astruc et al 2012). Starting from around 12,000 BC in the pre-Neolithic Natufian culture, these simple flint (or less commonly obsidian) blades were set in hafts of wood, handle or horn and glued with bitumen. Although obsidian was often obtained over great distances, much of the flint was available locally. Maeda et al (2016) argue that sickles were originally developed as a cutting tool for raw materials such as reeds and sedges. Later over the course of the 9th millennium BC in the Middle East they were transferred (as an exaptation) to agricultural harvesting. These early sickles were not entangled in very much; they were easily mended or replaced. Harvesting could also be carried out by uprooting or beating into baskets. Jump forward 14,000 years and this is how we harvest. The modern agricultural industry has become dependent on massive combine harvesters that 'combine' reaping, threshing and winnowing into one process. The labour savings are considerable, but these machines often cost $400,000, they have over 17,000 parts that are made all over the globe, and distributed to customers by for example the John Deere company through its Global Parts Distribution Network Strategy. The latter deals with 800,000 parts for different machines.

Or take the example of spinning. Sheep with woolly coats appeared late in the Neolithic of the Middle East, and the first spindle whorls for spinning wool occurred around 7500-7000 BC (Rooijakkers 2012; Zeder 2009). These small innocent whorls were easy to make from clay or stone, and the wooden sticks and the sheep's wool were all available locally and were easily replaceable. We can then follow through the development of spinning technology from the medieval spinning wheel, to different types of machine used to spin wool, linen and cotton. If we just take the case of cotton, the first cotton spinning machine was the spinning jenny, and then in the 1780s in Manchester spinning machines called water frames were used powered by water wheels, leading to the spinning mules that were powered by water or steam, leading directly to the vast spinning machines of today. Nowadays the making, producing and selling of a cotton T shirt is a massive global enterprise that on the one hand employs millions of people and connects the world, but also has serious environmental impact.

Or take the classic example of the invention of the wheel. Although text books often say that the wheel was invented in Europe and Asia in the 4th millennium BC, it is in fact very difficult to know what is the origin of the wheel. The idea of a rotating axle and wheel has many sources including spindle whorls that we have already seen began in the 8th millennium BC, and still earlier the rotating bow drill was used to make holes in beads (in the Upper Palaeolithic), and even earlier sticks rotated by hand were used to make fire. The potter's wheel emerges at about the same time as wheels used in transport but it is very difficult to say that they were connected. What is clear, however, is that after this early start from multiple origins, humans have increasingly made use of the multiple affordances of wheels – for transport, weaponry, the production of energy, the making of clocks and machines, tools and lathes, spinning wheels and machines, musical instruments and so on. It would be impossible to envisage present-day society without the wheel. For example, we have become thoroughly dependent on the car and so have become tied into a global trade in parts and have had to deal with the effects on global climate of the massive production of greenhouse gases. This slide attempts to summarize the long-term global proliferation of uses of the wheel. As in the other examples provided, early simple things and technologies have become greatly elaborated over time, have increased in number and embroiled humans yet more deeply in complex relationships with each other and the global environment.

It is difficult to draw out all the proliferation of the types of thing that I have been describing because the connections become so large. But on a smaller scale as an archaeologist it is possible to draw out the links on one site. So, for example, at the Neolithic site of Çatalhöyük that I excavate in Turkey the earliest pottery was made out of local clays using simple technologies and it was used as a container. Later the pottery was made with greater skill and pottery was used for cooking. Finally these functions were added to by using pots for storage, as well as consumption and social display, as seen in the painted decoration. Through time the affordances of pottery are gradually realized and the connections increase.

In these ways we can argue for an overall directionality in the human relationship with things. In all these examples and many others, we see a general pattern of increased exploitation of the affordances of things leading to more material culture, greater differentiation, increased use of resources, greater complexity. So my question is, why does this happen? I will start by considering answers given to these questions by theories of progress, and by theories of biological evolution, and briefly by complexity theories. I will then argue that entanglement theory offers a more adequate answer.

One possible answer is that this directionality is a sign of progress as humans increasingly used tools to capture energy from the environment in order to build civilization. The idea of progress is often thought to be a product of the 18th and 19th centuries AD, but a good case can be made that it has great antiquity, even present in the Greek and Roman worlds (Nisbet 1980). The early Christians, and especially St Augustine, described a necessary movement towards spiritual perfection – a millenarian movement of worldly struggle leading towards a promised golden age. Similar ideas of a necessary unfolding according to God's plan are found throughout the medieval period in Europe. The opening up of the Americas and other parts of the world through voyages of discovery presented the western world with a problem – how to make sense of the differences between these newly found societies and western societies? How could one locate them socially, economically, spiritually? This was done in a number of ways, but the most common was through the idea of progress – that 'they' were now as the West had been. The discoveries reinforced Eurocentric notions of superiority and advance through the idea of progress. Seeing 'them' as prehistoric savages justified exploitation and enslavement. The idea of progress reached its zenith in the West in the period 1750-1900 AD. It under-pinned colonialism and imperialism and all the other key ideas of this period like freedom, equality, social justice and popular sovereignty (Nisbet 1980). Set in the context of progress, each of these ideas became not just desirable but historically necessary, and inevitable. Comte, Hegel, Marx and Spencer (and later Talcott Parsons, Leslie White and many others) could all write a history of a slow, gradual and continuous and necessary ascent to some end. What is important in this period is the secularization of the idea of progress – wresting it from a divine plan and seeing it as a natural process, subject to scientific analysis. But each of these ideas of progress remained mired in special interests, whether it was the supremacy of Athens, the centrality of the church, or the imperial dominance of the West.

A further difficulty with ideas of progress is that they are teleological in that the thing to be explained (societies have attained objective science, complexity, democracy or freedom) is also the cause (societies progressed in order to achieve objective science, complexity, democracy or freedom). In addition they assume some inherent nature of the human species – to always want to progress. Unpopular through the later part of the 20th century, these ideas are still found today in evolutionary theory. For example, Smith (2012, 260) argues that Niche Construction Theory can explain 'initial domestication not as an adaptive response to an adverse environmental shift or to human population growth or packing but rather as the result of deliberate human enhancement of resource-rich environments'. This notion of humans consciously enhancing the density and productivity of desired resources is repeated by Zeder and Smith (2009, 688) and Zeder (2016). It is precisely this 'deliberate human enhancement' that needs to be explained rather than assumed. Another example of the way in which a progressive drive appears to underlie some contemporary evolutionary theory is the assumption that populations increase. For example, Niche Construction Theory often depends on population increase as a Macro-Evolutionary process (Smith 2012) that generates change. In fact it has proved very difficult to see this factor as an explanation for long-term change

(for a contrary view see Kremer 1993). In relation to the origins of agriculture in the Middle East, for example, population and resource pressures do not prove to be primary causes, and in any case it would still be necessary to explain why populations increase.
Does the parallel between cultural and biological evolution help to explain the directionality I have described? There are of course doubts (from Darwin to Dawkins, and see Fracchia and Lewontin 1999) about whether cultural and biological evolution can be seen as comparable or analogous. But even if we were to accept the comparison, can we argue that biological evolution has an overall direction? It is widely accepted that specific directionality occurs as organisms adapt to local environments. Positive natural selection drives the increase in prevalence of advantageous traits; an organism is gradually selected that has maximum fitness in a particular environment. Directional selection occurs when individuals with traits on one side of the mean in their population survive better or reproduce more than those on the other. But this process of local adaptation does not imply that there is a general direction to evolution.

It is often argued that in Darwin's theory of natural selection neither progress nor cumulative development play a significant role, although Nisbet (1980, 173) shows in a series of quotes that Darwin did have an overall notion of progress towards more perfect forms – the continued action of natural selection leads to a progressive development. S J Gould (1989) too ponders those segments of Darwin's writings in which Darwin proposes an overall progressive development. Gould explains these as a social response to the ideas of progress prevalent in Victorian imperial Britain. But Gould is very clear himself that genetic 'variation itself supplies no directional component' (ibid., 228), and he frequently says that if we were to rewind the tape of evolution different outcomes would occur because of the significant role of contingency and history.

Nevertheless it is often claimed that biological complexity has increased during organic evolution (eg Huxley 1946), because more complex organisms are argued to be able to survive better (although a claim might be made for the adaptive advantages of less complex organisms). As 'no agreement can be reached on how to measure complexity independent of the explanatory work it is supposed to do' (Fracchia and Lewontin 1999, 515; for a discussion of the different measures of biological complexity that have been proposed see Lineweaver et al 2013), it remains difficult to identify overall and general trends. One example that might be claimed is 'Cope's Rule' which states that there is selection for increasing body size. The first animals to evolve were tiny, whereas today many animal species are large. Was this increase in size due to active selection or to some more random process? Heim et al (2015) explored this hypothesis with regard to marine animals and found that indeed body volumes have increased by over five orders of magnitude since the first animals evolved. In addition, their modeling suggests that such a massive increase could not have emerged from a random process. And yet there remains much debate about this rule, and it does not hold true at all taxonomic levels, or in all clades.

General biological evolution is undoubtedly historical and path dependent. As with material culture change, genotypes tend to build on themselves instead of starting over. The Neo-Darwinian Synthesis proposes that the only significant constraints on evolution are imposed by the environment, but recent studies demonstrate that genotypes also impose constraints, and many of these are legacies of evolutionary paths taken long ago (Gould 1989). In these ways, as we shall see, there are parallels between biological and cultural evolution, but there seems to be no agreed account of general directionality in biological evolution. Survival of the fittest is not necessarily the same as survival of the most complex. We need to look elsewhere in the search for explanations of the overall directionality in human-thing relationships.

I do not have space to explore the question of whether complexity theory might help to explain overall directionality. Suffice it to say that a recent volume of papers by physicists, biologists and scientists studying the self-organizing of all complex systems found no consensus on either the questions 'what is complexity and how do we measure it' or the question 'does complexity increase?' (Lineweaver et al 2013).

These varied approaches (ideas of progress, biological evolution, and complexity theory), do not provide an explanation for the apparent overall increases in material culture, energy-capture, differentiation and complexity during human evolution. My view is that this is because attention has always focused on humans and their adaptations to the environments. Insufficient attention has been given to the role of things, to the things that humans make. Niche Construction Theory is one approach that pays attention to human-made material culture, but this theory too pays scant attention to the things themselves and I have already pointed to other problems with this approach.
Returning to the examples that I gave earlier in this talk, we can see 7 principles at work that lead to an understanding of directional change in human-thing relations.

1. No thing is a thing unto itself. I use the Anglo-Saxon word 'thing' here because its etymology refers to an assembly or bringing together in a 'ting'. In this talk I am mainly concerned with material things made by humans but I have argued elsewhere (Hodder 2012; 2016) that other types of things including concepts, institutions and even humans, may have similar properties to human-made matter. As Heidegger (1971) noted, all things draw together. Heidegger talked about this process in terms of a jug, but we can see the same process with the earliest pots made in the Neolithic of the Middle East. For example the earliest cooking pots at Çatalhöyük brought together existing ideas and technologies such as fired clay

(earlier used for figurines), containers (baskets and wooden bowls), water, fire, cooking hearth and the cooking of food. The making of pots also had a series of consequences such as more efficient cooking that allowed more activities to take place in the house, and pottery exchange. Similarly the wagon wheel brought together and was made possible by many other things and had innumerable consequences. Archaeologists are used to study the upstream-downstream processes, the chains of production, use and discard and all the other artifacts that make these operational sequences possible. The simple sickle was involved in complex operational chains associated with the domestication of plants.
It was wrong, therefore, to show you earlier linear sequences of the increasing complexity of wheels or harvesting tools or cotton spinning machines. In those diagrams the objects were 'objectified', but if we see them as 'things', we can explore their conditions and consequences. For example, the development of cotton spinning technologies in industrial Britain was closely tied to the trans-Atlantic trade in slaves, to the formation of factory labour and wage labour, the emergence of the proletariat and industrial capitalism, to the rise of the nation state, to colonialism, ships and trains, clocks and the telegraph (Beckert 2014). Today, each year 2 billion T shirts are sold worldwide; this not only uses huge amounts of water and energy, but also releases byproducts of starch, paraffin, dyes, pesticides and other harmful pollutants into the air and soil. Indeed from the horrors of slavery and child labour to William Blake's 'dark satanic mills' and more recent chemical pollution there has come to be a heavy social and environmental cost to spinning cotton. In India in 2005, after a poor growing season, hundreds of heavily indebted farmers of genetically modified cotton committed suicide by drinking their own pesticides.

2. There are thus webs of dependency in which humans depend on things so that they can do more and harness more energy (HT in this diagram). But these things on which humans depend also depend on many other things (TT) along the operational chains. For example, cotton depends on suitable soils and climate, and on the machines used to clean, spin and weave the cotton. But the processing of cotton is very arduous and requires a lot of labour both in the field and in the factory so that the cotton depends on humans (TH), and humans depend on other humans (for example slaves) in order to manage the processing (HH). There is thus not a network of interactions but a web of dependency. Rather than a network there is a binding, or what I call an entanglement of HT, TT, TH and HH dependencies. Humans get trapped or locked-in to these entanglements. If humans want to wear affordable cotton T shirts they get locked into international trade deals, long distance transport, the search for and exploitation of low wage workers, and into large-scale environmental impact. In fact, there is a 'double bind' in that humans depend on things that depend on them so that humans get drawn into their care.

3. These webs of dependency, these entanglements, are heterogeneous. They include humans and things certainly, but an enormous diversity of things from the physical to the metaphysical, from the social to the economic, from matter to biology (plant and animal). In the case of cotton we need to consider dependency on soils, climate, machines, ships and trains, clocks, on social movements and institutions, on colonialism and empire, and even dependency on ideas such as the idea of progress that under-pinned the rise of industrial capitalism in 19th century Britain. We are used, as a result of the work on Actor Network Theory and the New Materialisms to think of the mixed nature of these socio-material assemblages, although it is important again to emphasize that entanglements are webs of dependency, not networks (Latour 1999; 2005). Starch, pests and genes are important in the cotton story so that the overall heterogeneous web is bio-socio-material. There is mounting evidence that environmental, social, cultural, psychological factors can influence DNA expression. These extra- or epi-genetic factors can modify gene expression without altering the DNA sequence and they can be inherited, leading to a return to Lamarckian ideas about the inheritance of acquired characteristics long deemed irrelevant to evolutionary processes of transmission. Within the Extended Evolutionary Synthesis there is the potential to usher in a new era of integrated collaborative research (Barad 2007, Dickins and Rahman 2012, Jablonka and Lamb 2007, Keller 2014, Mesoudi et al 2013). Within the bio-socio-material entanglements there are varying processes at work.

4. The entanglements are unbounded. Biology and the environment are always already entangled in the social materiality of life. There is no environment separate from human intervention since the earliest humans; there is no niche into which organisms fit since the niche is always a product of the interactions within entanglements (Lewontin 2001). Adaptationist arguments fail because the definition of regions of study is always arbitrary. Entanglement theory takes a radically non-reductionist stance. In describing the entanglements of the wheel, it became very difficult to know what should and should not be included. Is a roller a wheel, and what of a bow drill and a spinning whorl? Since a wheel needs an axle, and an axle needs a frame, where is the boundary between the wheel and the wagon; and what about the cow or horse or internal combustion engine that drive the wagon or other wheeled vehicle? And what about the roads and the fuel, and the environment that are affected? A full understanding of the wheel needs to explore all the unbounded entanglements since very distant events can have quantum effects. For example, events in Saudi Arabia and the Gulf lead to price changes in oil and thus affect the numbers of wheeled vehicles on the roads in California. It is perhaps too trite to say that everything is connected to everything else, but you will have begun to notice that my disparate examples are in fact all connected – harvesting, cotton spinning, the wheel, pottery and ideas of progress.

5. There is a contingent non-systemness to entanglements. The heterogeneous and unbounded nature of the webs of dependencies create conflicts and contradictions. This is a logical result of the 3rd and 4th points. Given the many different

types of processes at work in entanglements, and given their far-flung character, there are bound to be conflicts and contradictions that are inherent or that emerge. At the most basic of levels, most human-made things bring biological life processes into conjunction with material physical processes. As Leslie White emphasized, while the biological lifeworld seeks to concentrate energy, the physical world tends towards entropy. Humans use chert sickles to obtain food but the humans then get tied into dealing with the fact that the chert tools get blunt, break and have to be replaced. Humans concentrate energy in their cars in order to travel to work but the fuel gets used up (entropy increases) so that the car user becomes dependent on the vagaries of the international trade in oil. Apparently distant, unrelated events can set off chains of reactions that ripple through the entanglements, as when an artist in Denmark draws a cartoon in a newspaper that incenses populations of different religions in the Middle East that then affects the price of oil and the numbers of cars on the streets in California. Or Mohamed Bouazizi sets himself on fire in a market in Tunisia and unwittingly starts the so-called Arab spring throughout the Middle East, again leading to changes in oil prices across the globe. In these examples, material, physical, social, religious, biological processes are all entangled in a thoroughly contingent, non-systemic way. Conflicts and contradictions emerge out of this messy set of inter-dependencies.
As another example, the development of cotton spinning machines in Manchester in the 1780s fueled the demand for slaves in the United States. The plantations with slaves could produce low cost raw cotton to fill the mills in industrial Britain. But the rise of an urban class of industrial magnates also fueled notions of social justice that led to the American Civil War and an end to slavery. This contradiction and the conflict of the American Civil War led to a decline in the production of cotton in the United States and cotton sourcing shifted to India (Beckert 2014). In these ways cotton, slavery and notions of social justice brought things, humans and ideas together and in conflict and contradiction with each other.

6. Humans deal with the contradictions, conflicts and problems by making use of the affordances of what they already have or by fitting new developments into existing entanglements and goals as best they can. Development is thus cumulative but path dependent. This is partly because so much gets invested in bio-socio-material entanglements that it makes sense to minimize disruption and change, but the main factor is that the entanglements are so large and non-systemic that radical change is difficult and risky. It tends to make more sense to fix things rather than start over. The cumulative process is seen in the gradual elaboration of the wheel, or in the gradual development of spinning machines. The design of the latter was initially based on hand spinning techniques, and on flax spinning machines. The rise of cotton manufacturing in Britain was built on the existing role in sea trade and contacts with India. The heterogeneous web of dependency between slavery, cotton, profit and ideas of progress and superiority got caught in a path dependency in which massive profits were made and in which masses of people suffered. It needed a very bloody civil war in the United States to break this path dependency. Today the wheel has drawn us into another path dependency. Developed societies are very dependent on cars even if they have very negative impacts on the environment. The webs of dependency bind us into pathways that have long-term impacts such as global warming that appear intractable precisely because the webs are so large.

7. From a long-term archaeological point of view, even taking booms and busts and violent revolutions and civil wars into account, change is continual, gradual and exponential. Cultural and technological growth are often argued to be exponential. For example, Moore's Law states that the processing power of a single chip or circuit will double every year. Presumably there is a limit to the exponential growth of such technological achievements. But the long-term increases in entanglements and amounts of material culture that I have been discussing also seem to be exponential. In my view this is simply because the gradual exploitation of the affordances of things also increases the numbers of entanglements of those things. Thus as spinning machines become elaborated and made more efficient, so their entanglements are multiplied. Or the wheel gradually becomes diversified, specialized and differentiated, and each new type or function of wheels has its own entanglement. The more new types of wheel, the more entanglements. The entanglements thus multiply in an exponential manner. The cone of increasing elaboration of a thing is associated with a cone of increasing elaboration of entanglement, creating exponential growth.

8. Change is thus directional in two senses:

(a) Specific directionality. This results from the particular things that are caught up in webs of dependency and on the cumulative nature of development. For example, it is often argued that the wheel developed in Eurasia because there were draught animals to pull carts and wagons. In the pre-Columbian Americas, wheeled vehicles were not used for transport. This was not because humans could not come up with the idea of the wheel, as the existence of toy wheeled vehicles in Olmec sites in southern Mexico makes clear (Bulliet 2016). Many other factors were probably involved (ibid), but the specific array of things available certainly resulted in different directions being taken in different bio-socio-material contexts. And when different bio-socio-material entanglements come into contact the results can be catastrophic. The title of Diamond's (1997) 'guns, germs and steel' provides part of the answer for the violent transformations that engulfed the Americas as a result of colonial intervention, but wheels, cotton, harvesters and ideas of progress also played their roles, along with many other heterogeneous entanglements.

(b) General directionality. As I showed at the start of this talk, it is difficult to refute the archaeological evidence for an overall and exponential increase through time in the ability of humans to capture energy and in the complexity and amount of material things and the entangled webs of dependency. In my view this is the logical result of the seven points that I have made in this talk. The overall directionality results from the 'thingness of things'. The distinctive component of the approach that I have been outlining is that it gives a central role to things. The approach explores the ways in which things pull other things and humans towards them. Humans get caught up in managing the entanglements on which they depend. But they are therefore bound to something unbounded. The bio-socio-material entanglements are heterogeneous and open-ended, incorporating many different types of biological, social, material, ideological process. There are thus always contradictions in the various parts that things draw together. There are always conflicts and problems and contingent interactions that emerge within bio-socio-material entanglements. Humans are caught up in things, and humans and things are dependent on each other, and so humans have to deal with consequences and with the quantum events that seem to come 'out of left field', difficult to predict and control. In fixing problems and in reacting to events, humans do what they have always done, find another thing, tweek the machine, manage with what resources are available. The entanglements thus expand and the human entrapment in things is continued. At some point, when the entanglements around any one thing such as a wheel become too large it becomes impossible to turn back. It is no longer possible to rewind the tape. Too much is caught up and too much is at stake. It would be nice if we could respond to global warming by getting rid of cars. But cars and wheeled vehicles are so integrated into modern life that it would be impossible to run a major contemporary city without them. So rather than getting rid of cars we seek other solutions, which often only increase entanglements, as seen in the enormous battery factories being built by Tesla.

I would argue that entanglement theory provides a non-teleological framework for understanding the long-term directionality of humans towards greater entanglement and dependence on things. Our dependence on things has meant that we can be more complex and take more energy from the environment, but it has also meant that we are increasingly trapped and unable to solve global-scale problems. Another interesting trend is that thing-thing dependencies seem to be taking over from human-human relationships. Very few people work in the huge Tesla factories. Some Tesla and Google cars are driverless. Combine harvesters feel their own way around fields of crops; the driver is not needed. The human has been displaced. Charlie Chaplain was surely right in his depiction of Modern Times.

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Bibliography

Astruc, L., Tkaya, M.B. and Torchy, L., 2012. De l'efficacité des faucilles néolithiques au Proche-Orient: approche expérimentale. *Bulletin de la Société Préhistorique Française*, 109(4), pp.671-687.

Barad, K., 2007. *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning.* Duke University Press.

Baumard, N., Hyafil, A., Morris, I. and Boyer, P., 2015. Increased affluence explains the emergence of ascetic wisdoms and moralizing religions. *Current Biology*, *25*(1), pp.10-15.

Beckert, S. 2014. *Empire of Cotton. A Global History.* New York: Vintage.

Bulliet, R W 2016. *The Wheel. Inventions and Reinventions*. Columbia University Press.

Cane, S. 2013. *First Footprints. The Epic Story of the First Australians.* Crows Nest, Australia: Allen and Unwin.

Diamond, J. 1997. *Guns, Germs and Steel. The Fates of Human Societies.* New York: Norton.

Dickins, T.E. and Rahman, Q. 2012. The extended evolutionary synthesis and the role of soft inheritance in evolution. In *Proceedings of the Royal Society B* (p. rspb2012.0273).

Fracchia, J. and Lewontin, R.C., 1999. Does culture evolve?. *History and Theory*, *38*(4), pp.52-78.

Gould S J 1989. *Wonderful Life. The Burgess Shale and the Nature of History.* London: Norton.

Heidegger, M. 1971. *Poetry, Language, Thought*. (Translated by A. Hofstadter) London: Harper.

Heim, N.A., Knope, M.L., Schaal, E.K., Wang, S.C. and Payne, J.L., 2015. Cope's rule in the evolution of marine animals. *Science*, *347*(6224), pp.867-870.

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

Hodder, I. 2016. *Studies in Human-Thing Entanglement.* http://www.ian-hodder.com/books/studies-human-thing-entanglement

Huxley, J. 1946. *UNESCO Its Purpose and Philosophy.* London: Euston Grove Press.

Jablonka, E. and Lamb, M.J., 2007. Précis of evolution in four dimensions. *Behavioral and Brain Sciences*, *30*(04), pp.353-365.

Keller, E.F., 2014. From gene action to reactive genomes. *The Journal of Physiology*, *592*(11), pp.2423-2429.

Kremer, M., 1993. Population growth and technological change: one million BC to 1990. *The Quarterly Journal of Economics*, *108*(3), pp.681-716.
Latour, B. 1999. On recalling ANT. In J. Law and J. Hassard (eds.), *Actor Network Theory and After*. Oxford: Blackwell and the Sociological Review, 15-25.
Latour, B. 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.
Lewontin, R.C., 2001. *The Triple Helix: Gene, Organism, and Environment*. Harvard University Press.
Lineweaver, C.H., Davies, P.C.W. and Ruse, M. 2013. What is complexity? Is it increasing? *Complexity and the Arrow of Time*, (eds.) Charles H. Lineweaver, Paul C. W. Davies and Michael Ruse. Cambridge: Cambridge University Press. 3-16.
Maeda, O., Lucas, L., Silva, F., Tanno, K.I. and Fuller, D.Q., 2016. Narrowing the harvest: Increasing sickle investment and the rise of domesticated cereal agriculture in the Fertile Crescent. *Quaternary Science Reviews*, *145*, pp.226-237.
Mesoudi, A., Blanchet, S., Charmantier, A., Danchin, E., Fogarty, L., Jablonka, E., Laland, K.N., Morgan, T.J., Müller, G.B., Odling-Smee, F.J. and Pujol, B., 2013. Is non-genetic inheritance just a proximate mechanism? A corroboration of the extended evolutionary synthesis. *Biological Theory*, *7*(3), pp.189-195.
Morris, I., 2010. *Why the west rules-for now: The patterns of history and what they reveal about the future*. Profile books.
Morris, I., 2013. *The measure of civilization: how social development decides the fate of nations*. Princeton University Press.
Nisbet, R.A., 1980. *History of the Idea of Progress*. New Brunswick: Transaction pub