

A Single Historical Continuum

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“In our own generation we have been able to visualize our past as human beings in the context of geological time and the prehistoric basis of our recorded history” [1, p.124]

In the middle of the twentieth century our understanding of the past underwent a quiet revolution whose full implications have yet to be integrated into modern historical scholarship. At the heart of the revolution were new chronometric techniques, new ways of dating past events.¹ For the first time, these techniques allowed the construction of reliable chronologies extending back before the first written documents, before even the appearance of the first humans, back to the early days of our planet and even to the birth of the Universe as a whole. This expanded timeline provided the foundation for the “Single Historical Continuum” of my title. This paper describes the chronometric revolution and the creation of a single historical continuum. It then discusses some of the implications of these changes for our understanding of “history.” I am a historian by training so that, despite an enduring amateur interest in the sciences, my account of the chronometric revolution reflects the somewhat intuitive pattern-seeking methodologies of my discipline, rather than the often more rigorous, and more mathematical methods of the natural sciences. I will argue that the chronometric revolution requires a fundamental re-thinking of what we understand by “history.”

History before the Chronometric Revolution

Historical scholarship has traditionally been confined to the study of human societies. There were many reasons for this bias. One that is often ignored is the technical fact that until very recently the only way to reliably date past events or objects was by using written documents generated by our human ancestors. Though often taken for granted by historians, good timelines are fundamental to historical scholarship because without them events cannot be ranked chronologically and there can be no serious discussion of sequence or causality. History fades into myth. So the use of written records to create reliable timelines was fundamental to historical scholarship. Yet it also limited

¹ Parts of this paper are based on an earlier paper about the chronometric revolution: “Historia, complejidad y revolución cronométrica” [“History, Complexity and the Chronometric Revolution”] [2].

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Citation: Christian, David. 2011. A Single Historical Continuum. *Cliodynamics* 2: 6–26.

what historians could study for it meant that good timelines were available only for the history of literate human societies. The result? History as a serious scholarly discipline came to mean human history rather than the study of the past as a whole.

Reliance on written records set chronological as well as topical limits. “History cannot discuss the origin of society,” wrote Ranke in the 1860s, “for the art of writing, which is the basis of historical knowledge, is a comparatively late invention. ... The province of History is limited by the means at her command, and the historian would be over-bold who should venture to unveil the mystery of the primeval world, the relation of mankind to God and nature.”² When pushed to their limits, written records could take scholars back at most 5,000 years, for that was when writing first appeared.³ Beyond this chronological barrier, there could be no serious history. Of course, lack of chronological evidence did not prevent speculation. Christian tradition argued on the basis of biblical genealogies that God had created the earth about 6,000 years ago. Some traditions imagined even older Universes.⁴ But none of these chronologies could claim the objectivity, the precision or the fixity of those based on written records.

It is a remarkable, and often ignored, fact, that the 5,000 year chronometric barrier was finally crossed only in the mid twentieth century. Until then, even archaeologists had to rely for absolute dates on the written record. As Renfrew and Bahn write: “Before World War II for much of archaeology virtually the only reliable absolute dates were historical ones – Tutankhamun reigned in the 14th century BC, Caesar invaded Britain in 55 BC” [5, p.101]. These chronometric limitations help explain why even today the “history” taught in modern Universities is essentially the history of literate human societies during the last 5,000 years. However, the research that would eventually break the chronometric barrier had its roots in the era of the scientific revolution.

In seventeenth century Europe, growing interest in geology and in fossils encouraged the idea that the earth had to be more than 6,000 years old. Nils Steensen, usually known as Steno, found fossils of what appeared to be marine

² Cited in Dan Smail [3, p.1350].

³ And even then, the evidence is often indirect. For example, evidence such as the Egyptian dynastic records carved on the famous Palermo stone (dating to about 2,500 BCE), can be used to generate plausible timelines reaching back another 500 years or so, but only on the assumption that they, in turn, used earlier written records.

⁴ “Suppose, O Monks – said the Buddha – there was a huge rock of one solid mass, one mile long, one mile wide, one mile high, without split or flaw. And at the end of every hundred years a man should come and rub against it once with a silken cloth. Then that huge rock would wear off and disappear quicker than a world-period [*kalpa*]. But of such world-periods, O Monks, many have passed away, many hundreds, many thousands, many hundred thousands.” Cited from Mahathera [4].

organisms in rocks high in the hills of Tuscany. In his *Prodromus*, published in 1671, he argued that marine fossils could appear in mountains only if the rocks containing them had once been beneath the sea. Though Steno resisted the idea that such changes must imply an earth older than the biblical 6,000 years, others were less cautious. The eighteenth century naturalist, Buffon, argued that it might be possible to date events by using the natural world as a sort of historical archive:

Just as in civil history we consult warrants, study medallions, and decipher ancient inscriptions, in order to determine the epochs of the human revolutions and fix the dates of moral events, so in natural history one must dig through the archives of the world, extract ancient relics from the bowels of the earth, gather together their fragments, and assemble again in a single body of proofs all those indications of the physical changes which can carry us back to the different Ages of Nature. This is the only way of fixing certain points in the immensity of space, and of placing a number of milestones on the eternal path of time [6, p.144].

Just before the French Revolution, using an idea already suggested by Newton (only to be immediately rejected), Buffon tried to date the earth itself by assuming it was a cooling body that had once been molten [6, pp.146-147]. His calculations suggested that it must be at least 100,000 years old, and perhaps much older. His contemporary, James Hutton, went further. Writing in 1788, he described an earth shaped by endless cycles of erosion and uplift and concluded that there could be found: “no vestige of a beginning, – no prospect of an end” [6, p.157]. In the nineteenth century, the emergence of thermodynamics revived interest in the idea that the Sun and earth were both cooling bodies. Lord Kelvin estimated that the Sun had to be at least 500 million years old, but that on a rapidly cooling earth, life could not have existed for more than a few million years [6, p.223]. Though speculative, his conclusions carried enough weight to embarrass Darwinians. But the truth was that at the end of the nineteenth century it was still impossible to assign reliable absolute dates to any events before the appearance of the first written records.

Meanwhile, geologists had made significant progress with the task of constructing *relative* time-lines. They did so by identifying and ranking different geological strata, and correlating them according to the fossils they contained, a technique pioneered by an English surveyor, William Smith early in the nineteenth century. But without absolute dates, no one could tell, within several orders of magnitude, when these geological strata had been laid down.

What the pioneers of modern chronometry did show was that time was deep. There had been plenty of history *before* the appearance of the first written records, and even before the appearance of the first human beings. This implied that it should be possible to imagine a single historical continuum extending back to the origins of time itself, and uniting human history with the history of the natural world. Toulmin and Goodfield [6, p.130] describe Kant's *General History of Nature and Theory of the Heavens* (1755) as "the first systematic attempt to give an evolutionary account of cosmic history....". Kant imagined an infinite and infinitely old Universe in which gravity would gradually clump matter into more and more ordered regions until the entire Universe collapsed in a "big crunch" which would scatter matter once more through the Universe, allowing the entire process to repeat. In his *Ideas towards a Philosophy of the History of Man*, Herder tried to integrate human history into the larger story of cosmic evolution. In the nineteenth century, the notion of a single historical continuum would shape the work of many social and historical thinkers, including Hegel and Marx. To the pioneering British archaeologist, John Lubbock, whose *Prehistoric Times* was published in 1865, it already seemed natural to treat human prehistory as part of a larger story that embraced geology and even astronomy. As Clark puts it, Lubbock: "discussed human biological and cultural evolution in universal terms" [1, p.121].

However, nineteenth century attempts to construct a single historical continuum were highly speculative, and without the chronological mooring of absolute dates they drifted helplessly in relative time. This may help explain why, late in the nineteenth century, historians lost interest in the idea of a single historical continuum. As historical scholarship became more "scientific" historians retreated from such large speculative matters, and returned to human history and the documents that recorded it. The modest work of building up a reliable database of dateable information about the recorded past – that was the way to ensure that history maintained its scientific credibility. Henri Houssaye thundered at the opening session of the First International Congress of Historians in 1900: "We want nothing more to do with the approximations of hypotheses, useless systems, theories as brilliant as they are deceptive, superfluous moralities. Facts, facts, facts – which carry within themselves their lesson and their philosophy. The truth, all the truth, nothing but the truth" [7, pp.37-38]. Houssaye's naive inductionism became the dominant methodological slogan of historical scholarship in the early twentieth century. In their *Introduction to the Study of History* of 1898, Langlois and Seignobos [3, pp.1350-1351] wrote: "The historian works with documents. Documents are the traces which have been left by the thoughts and actions of men of former times ... No documents, no history."

In this climate, the few historians who persisted in the search for larger historical patterns invited the scorn of their colleagues. The English historian,

Hugh Trevor-Roper, wrote of Toynbee's *Study of History*, that "as a dollar earner ... it ranks second only to whiskey" [8, p.108]. Toynbee himself was confident that eventually he would be vindicated. Early in the 1960s, in an interview with Ved Mehta:

he comforted himself with the thought that the days of the microscope historians were probably numbered. They, whether they admitted it or not, had sacrificed all generalizations for patchwork, relative knowledge, and they thought of human experience as incomprehensible chaos. But in the perspective of historiography, they were in the minority, and Toynbee, in company with St. Augustine – he felt most akin to him – Polybius, Roger Bacon, and Ibn Khaldun, was in the majority [8, p.143].

At the time, Toynbee's hopes seemed utterly Utopian.

As the scope of respectable historical scholarship narrowed once more, some concluded that there was a fundamental epistemological divide between History and the Natural Sciences. The great English historiographer, R.G. Collingwood explicitly raised the notion of a single historical continuum only to dismiss it.

The methods of historical research have, no doubt, been developed in application to the history of human affairs; but is that the limit of their applicability? They have already before now undergone important extensions: for example, at one time historians had worked out their methods of critical interpretation only as applied to written sources containing narrative material, and it was a new thing when they learnt to apply them to the unwritten data provided by archaeology. Might not a similar but even more revolutionary extension sweep into the historian's net the entire world of nature? In other words, are not natural processes really historical processes, and is not the being of nature an historical being? [9, p.210]

Collingwood did not fall for the already outdated notion that history dealt with unpredictable, contingent processes while the natural sciences dealt with processes that were more regular, law-abiding and predictable. "With Darwin," he wrote, "the scientific point of view capitulated to the historical, and both now agreed in conceiving their subject-matter as progressive" [9, p.129]. What really distinguished historical scholarship in his view was that it dealt with an unpredictable world of conscious acts rather than merely with events. "The

events of nature are mere events, not the acts of agents whose thought the scientist [i.e., historian, DGC] endeavors to trace” [9, p.214]. The historian’s goal, therefore, was not to seek general laws, but to “penetrate” the thoughts that motivated past actions. That was why historians seemed to occupy a different epistemological universe from natural scientists.

The Chronometric Revolution and the Creation of a Single Historical Continuum

Dropping the idea of a single historical continuum made sense given the limitations of nineteenth century dating techniques. Over the next century, historians would make great progress in the more manageable project of documenting human history as thoroughly as possible using written evidence. Indeed, so absorbing was this challenge that few historians noticed when, in the middle of the twentieth century, it suddenly became possible to construct reliable timelines extending back to the origins of time itself.⁵

In the two decades after World War II, the notion of deep historical time acquired a firm scientific foundation as a result of breakthroughs in biology, geology and cosmology. Discovery of the genetic role of DNA in 1953 put evolutionary theory on an entirely new footing; discovering and unraveling the meaning of deep ocean trenches helped clinch the new theory of plate tectonics; and the discovery of the Cosmic Background Radiation in 1964 provided empirical evidence for big bang cosmology. Each of these breakthroughs assumed the reality of deep time and of long-term historical change. This story is too well known to be described in more detail here.⁶

Less well appreciated is the significance of what I have called the “chronometric revolution.” This provided the dating techniques needed to revive the idea of a single historical continuum. Ironically, the crucial breakthrough was the discovery of radioactivity by Henri Becquerel and Marie and Pierre Curie in the last decade of the nineteenth century, just as historians began to turn away from the idea of a single historical continuum. Radioactivity explained why the calculations of Buffon and Kelvin could be wrong by so many orders of magnitude. The earth was indeed a cooling body; but it also contained an internal source of heat previously unknown to science. In the first decade of the twentieth century Ernest Rutherford showed that radioactive materials decayed with such regularity that they could provide the natural clocks that Buffon had searched for in vain. Armed with knowledge of an element’s half-life (the time in which half its mass decays), it should be

⁵ You will find no references to radiometric dating and its significance in standard surveys such as Georg Iggers [10] or Joyce Appleby, Lynn Hunt and Margaret Jacob [11].

⁶ A brief account written by a historian for historians is William H. McNeill [12].

possible to calculate when a lump of matter containing that element had originally formed by determining what proportion of it had decayed. Rutherford demonstrated his idea as early as 1905 by calculating that a piece of pitchblende (an ore of uranium) must have been formed about 500 million years ago.⁷ The technique Rutherford pioneered has come to be known as “radiometric dating.”⁸

However, many difficulties had to be overcome before radiometric dating could be used routinely to determine absolute dates. So the revolutionary implications of this demonstration would not become apparent until after World War II. During the war, Willard F. Libby of the University of Chicago had worked on the Manhattan project, developing precise methods for separating different isotopes of Uranium. This was the crucial skill needed to measure precisely the extent of decay of radioactive materials. After the war, Libby developed similar techniques for measuring the proportion of Carbon 14, a rare and unstable isotope of Carbon, in samples of organic material. Because all living organisms take in carbon dioxide while alive, this is an ideal technique for dating organic remains. The relatively short half-life of Carbon 14 (about 5,600 years) also makes it highly suitable for archaeology, because it can be used to determine dates from a few centuries to about 50,000 years, and the technique of accelerator mass spectrometry can extend that range to close to 80,000 years. Other radiometric techniques were soon developed. For example, thermoluminescence dating and electron spin resonance, though less precise than radiocarbon dating, can be used over several hundred thousand years, and in this way they can fill in the eras beyond the reach of Carbon 14 dating but below the reach of other techniques using materials with much longer half lives. Potassium/Argon dating depends on the breakdown of Potassium 40 to Argon 40, and because the half-life of potassium 40 is 1.25 billion years, it can be used for scales from 100,000 years up to the age of the earth. Similar techniques, based on the radioactive breakdown of Uranium in meteorites, were used in 1953 by Clair Patterson to determine the first accurate date for the formation of the earth (ca. 4.5 billion years).

Improvements in the accuracy and reliability of radiometric techniques stimulated the development of new, non-radiometric dating techniques. In 1965, Hans Suess showed that the relative amounts of different isotopes of carbon in the atmosphere were not constant, as Libby had assumed, and these changes could distort C 14 dates, sometimes by thousands of years. So alternative dating methods had to be developed to calibrate C 14 dates in

⁷ His demonstration immediately challenged the shorter chronology championed by Lord Kelvin.

⁸ There are many good, brief discussions of radiometric dating techniques. I have relied, in part, on Neil Roberts [15, pp.9-26]. Colin Renfrew and Paul Bahn [14, ch. 4] offers a good survey of modern dating techniques from the perspective of archaeology.

different eras. Of these, the most important was “dendrochronology,” a non-radiometric technique based on the counting of tree-rings. The idea of using such techniques is very old, but as a practical dating technique it was developed by A.E. Douglass (1867-1962) in the American Southwest. Analogous techniques have been developed using patterns of annual sedimentation in lakes (varve analysis, a technique pioneered by a Swedish geologist, Baron Gerard de Geer in the late nineteenth century), or the annual sequences in which ice is laid down in ancient ice sheets.

Meanwhile, genetic dating techniques helped put evolutionary biology on a firmer chronological footing. They depend on the realization that much genetic change (for example in mitochondrial DNA or in so-called “junk” genes) is effectively random. This means that alterations in gene frequencies can be used (after careful calibration) to estimate the evolutionary distance between different species. Techniques such as these have revolutionized understanding of human evolution, by showing that the human and ape lines diverged approximately 7 million years ago. Dating the age of the Universe became a viable challenge with the rise of big bang cosmology. Since Edwin Hubble first proposed that the Universe was expanding, there have been attempts to estimate the age of the Universe by measuring the rate at which it is expanding today, the so-called “Hubble constant.” The practical difficulties of determining the Hubble constant are immense, primarily because of the difficulty of establishing the distance of remote galaxies. However, present estimates, combined with alternative methods of dating the big bang, are converging on a date of about 13.7 billion years.⁹

History after the Chronometric Revolution

The armory of new dating techniques developed during the chronometric revolution made it possible for the first time to construct an objective, scientifically rigorous and increasingly detailed timeline for the entire past. The techniques are now so familiar that it is easy to take them for granted. Yet the full implications of the chronometric revolution have still not been incorporated within modern historical scholarship. The rest of this paper will describe some of these implications. Though I will focus on the implications for the History discipline, the discussion is really about the possibility of a grand unification of historical research within the framework of a single historical continuum.

⁹ Current estimates put the Hubble Constant at about 71 kilometers per second per megaparsec, which implies that the Universe is about 14 million years old; this estimate is remarkably close to estimates based on radiometric dating of the ages of the oldest stars, and on detailed analysis of tiny variations in the temperature and density of the Cosmic Background Radiation.

1. Redefining History: If there is, indeed, a single historical continuum it ought to follow that there is an underlying unity to all forms of historical research. All the disciplines that make up the continuum describe and explain change in the past even if they work on different parts of the continuum, operate at different scales, use different methods and paradigms, and focus on very different types of objects. The single historical continuum does indeed appear, as Collingwood put it, to “sweep into the historian’s net the entire world of nature.” This ought to mean that scholars in these disciplines have much to learn from each other, and students have much to learn from understanding what links different parts of the historical continuum. Indeed, the existence of a single historical continuum makes it anachronistic to describe as “History” a scholarly discipline that concerns itself only with part of the past of our own species. Logically, we should apply the label to all disciplines researching the past. Though such rearrangements would encounter significant resistance, it would make pedagogical sense, for example, if Universities were to group all the historical sciences within a single “College” or “School” of Historical Sciences. In such a context, the discipline traditionally called “History” would presumably have to be re-badged as “Human History.” (However, in this paper I will continue to refer to it as History with a capital H.)

Within the natural sciences the assumption of an underlying unity between different disciplines is taken for granted. As E.O. Wilson puts it: “The Natural Sciences have constructed a webwork of causal explanation that runs all the way from quantum physics to the brain sciences and evolutionary biology... The explanatory network now touches the edge of culture itself” [15, p.137]. However extending Wilson’s explanatory network to the Humanities, and to History in particular, remains a difficult challenge, for few historians seem willing to move outside the 5,000 year framework that has framed the discipline for so long. Even within sub-disciplines such as “world history,” the vast bulk of contemporary scholarship focuses on the period since 1500 CE.¹⁰ Are there good intellectual reasons for the continued isolation of disciplines such as history? Or is the separation largely a matter of institutional and intellectual inertia, of ancient habits of thought and scholarship? My own belief, after twenty years experience of trying to construct a University program embracing the entire historical continuum, is that the chronometric revolution has removed some of the most important barriers between history and the sciences. There now exist no serious intellectual or scientific or philosophical barriers to a broad unification of historical scholarship.¹¹ The barriers that remain are institutional and conventional. They are nevertheless

¹⁰ In a recent conference on Research Agendas in World History, only 4 of 36 presenters were researching eras before 1500 CE [16, pp.3, 20].

¹¹ On this course and the story it tells, see David Christian [17, 18].

significant as they are embedded in institutional structures such as modern scholarly journals and associations, and in patterns of recruitment and training which, like the conventional PhD dissertation, assume traditional definitions of the meaning of good scholarship. Overcoming these barriers will require a fundamental re-thinking of what history means within the single historical continuum.

However, historians also have much to gain by trying to integrate their discipline within the single historical continuum. Above all, they can begin to see their own research within a larger context. Historians are accustomed to see the principle that understanding something as complex as human societies means understanding their origins and roots. How can we understand modern China without understanding the role of Mao, or the decline of the Qing dynasty, or even the foundational role of the Han dynasty? Can we understand the role of the major religions without understanding their origins and histories? Yet exactly the same principle applies to human society as a whole. How can we understand the complex societies that generated the first written records without understanding the simpler societies from which they evolved? What was the source of the technological and artistic creativity that generated them? Such questions lead us quickly back to questions about the origins of our species and the nature of our distinctiveness as a species. In other words, the single historical continuum provides a way of integrating historical scholarship within the larger explanatory networks of modern science as a whole. By doing so, it promises to deepen our understanding of historical processes by tracing human societies to their paleolithic and pre-paleolithic roots. Before the chronometric revolution such questions could not be pursued seriously. Now they can be.

In the rest of this paper, I will explore some of the questions historians will face as they engage more seriously with the single historical continuum. I will focus on three main problems. First, is there a single explanatory or thematic network that embraces all the historical disciplines? Can there be any coherence to accounts of the past that traverse so many diverse disciplines? Second, will the traditional History discipline dissolve within the single historical continuum? Or will its identity perhaps become clearer within this larger framework? Third, how will integration within a single historical continuum affect the research methods and paradigms of historians? How will it affect the questions historians ask, the evidence they use, and the way they think about history in general?

2. Complexity as a Unifying Theme for an expanded view of History: Many important themes unite the different disciplines of the single historical continuum, beginning with questions about the nature of change and of time itself. One of the most powerful of these themes may turn out to be that of complexity. During 14 billion years, the level of complexity of the most

complex entities in the Universe seems to have risen. Where once there existed little more than energy, dark matter, and hydrogen and helium atoms, distributed more or less randomly through an expanding space, there have since appeared galaxies and stars, almost 100 new chemical elements, planets, living organisms and human beings. As Richard Dawkins puts it:

There is a hierarchy, ranging from fundamental particles below the atomic level up through molecules and crystals to the macroscopic chunks which our unaided sense organs are built to appreciate. Living matter introduces a whole new set of rungs to the ladder of complexity: macromolecules folding themselves into their tertiary forms, intracellular membranes and organelles, cells, tissues, organs, organisms, populations, communities and ecosystems. ... At every level the units interact with each other following laws appropriate to that level, laws which are not conveniently reducible to laws at lower levels [19, pp.112-113].

Is it possible that this large story may have something to teach historians about the evolution of complexity within human societies?

Eric Chaisson has suggested that it might be possible to quantify increases in complexity by measuring the “free energy rate densities” of different complex entities, the amounts of free energy flowing through a given mass in a given amount of time.¹² Whether or not this idea is correct, the general idea of increasing complexity can help us to think of galaxies, stars, planets, living organisms and modern human societies as different expressions of similar underlying processes of change. That idea, in turn, suggests an entire research agenda about the similarities and differences between different levels of complexity, and the processes that generated them. Is it true that increasing complexity in human history has also been associated with increasing energy flows? (The answer, as we will see, is “yes.”) If so, why? And how and why were those energy flows generated?

3. What makes “human history” distinctive? The idea of increasing complexity also suggests a helpful way of distinguishing between the different entities studied within the single historical continuum. Different levels of complexity appear to yield new “emergent properties,” properties that can not be deduced from understanding lower levels in the hierarchy. This means we can usefully ask: what are the emergent properties studied at each level, from sub-atomic physics, to the molecular level of chemistry, to the level of galaxies,

¹² Eric Chaisson [20, pp.132-135] expresses the free energy rate density in units of energy per time per mass.

stars and planets, and on to the level of complexity represented by living organisms. How do these levels differ? How are more complex entities built up from less complex entities? Such questions are familiar within the natural sciences, but the idea of a single historical continuum encourages us to extend them to human history as well.

Within such a framework, it is natural to ask whether there may be emergent properties that distinguish human history from the histories of all other organisms, including our close relatives, the great apes? Does human history represent a new level of complexity? If so, can we perhaps define History more precisely than Collingwood did, with his insistence that human history is distinguished primarily by the unpredictable, subjective decisions of individual actors? I believe we can. The suggestions that follow are tentative, though I believe they are compatible with a significant body of recent work on the evolution and early history of our species.

The best evidence that human history represents a new level of complexity can be found in the accelerating human control over biospheric resources. Human energy use has increased by about 200 times in just the last thousand years, and even per capita energy use (the amount used on average by each individual) has increased by almost 10 times.¹³ According to some estimates, our species may now be controlling, consuming or destroying between 25 and 40 per cent of all the carbon fixed by plants and other photosynthesizing organisms on land.¹⁴ No single species has ever enjoyed the degree of biospheric control that our species collectively enjoys today.¹⁵ Vaclav Smil writes: “The diffusion and complexification of human societies have led to a large array of environmental changes that have transformed this planet during the past 5 ka, and particularly during the past 100 years, more rapidly than any other biogenic process in the planet’s history” [22, p.240]. That these revolutionary changes are accompanied by a rapid increase in rates of extinction of other species, and by signs of global climate changes should not seem surprising.

¹³ Christian [18, p.141], using estimates from I.G. Simmons [21 p.27].

¹⁴ Vaclav Smil [22, p.240] strictly, what is being measured is global terrestrial Net Primary Productivity, the amount of carbon fixed by photosynthesizing organisms on land minus the amount they return to the atmosphere through respiration [22, p.182].

¹⁵ Groups of species, such as the social insects, have indeed had significant environmental impacts, but not as single species. They acquired their ecological power in genetic rather than cultural time, and it is this acceleration in the pace of change in the human era that needs to be explained. But even when compared with whole groups of species, the human impact is striking. For example, Vaclav Smil estimates that collectively all modern species of termites may account for about 25% of all global terrestrial Net Primary Productivity, which is close to the lower estimates for contemporary human impacts [22, p.222].

What is less obvious is that these changes are not confined to the modern era of human history, or even to the 5,000 years of traditional historical scholarship. Their roots lie deep in the Paleolithic era. For most of the 200,000 or so years since modern humans first evolved, our species' extraordinary ecological virtuosity has shown up most clearly in migrations to new environments requiring new forms of adaptation [22, p.231]. Spotty evidence for increasing human artistic and technological creativity appears within Africa from perhaps as early as 250,000 years ago, and then becomes impossible to ignore from 50,000 years ago. That is when our ancestors became the first large mammals to enter the Australian continent, after what must have been a technologically demanding sea-crossing. The settling of ice-age Siberia from perhaps 30,000 years ago required even greater technological skills as our ancestors adapted to cold climates by improving their control of fire, their ability to hunt large animals such as mammoth, and their tailoring and building skills. By 10,000 years ago, humans had settled all continents except for Antarctica. The number of humans rose from a few hundred thousands to 5 or 6 millions by 10,000 years ago.¹⁶ By then, our species was already having a significant impact on the biosphere. The widespread practice of firing the land altered biota over large areas (the evidence is particularly clear from Australia); while improved hunting methods may help explain the disappearance of many large animal species in regions of recent colonization (Australia, Siberia and the Americas) during the last 50,000 years.¹⁷ The emergence of agriculture in different parts of the world from about 10,000 years ago sharply increased human control over resources and allowed for the emergence of dense, compact and increasingly complex communities. The pace of technological change accelerated. Another significant gear shift in human numbers, social complexity and ecological impacts has occurred with the emergence of modern industrial societies. To give just one spectacular example, John McNeill estimates that by the end of the twentieth century human activities (above all mining and various forms of human-caused erosion) were moving about 42 billion tons of rock and soil every year. This is more than wind (1 billion tons), glaciers (4.3), mountain building processes (14), and oceanic volcanoes (30) and is exceeded only by the impact of moving water (53 billion tons) [26, p.30].

It may help to think of three interlinked vectors at work, with many others working in the background. The three main vectors of human history are

¹⁶ See, for example, the estimates in Massimo [23, p.31]. There is now powerful genetic evidence of a sharp drop in human numbers to perhaps as few as 10,000 individuals about 70,000 years ago, caused, perhaps by sharp climatic deterioration or even by a huge volcanic eruption in Indonesia, creating a "volcanic" winter. See Chris Scarre [24, p.140].

¹⁷ For accounts of how these processes worked in Australia, see Tim Flannery [25].

increasing control over biospheric resources leading to increasing populations leading to increasing social complexity, in a powerful feedback cycle. The contrast with our closest relatives, the great apes, is striking. For apes, we have no evidence of significant migrations in the same period, or of significant increases in ape populations or social complexity, or of measurable increases in ape control of biospheric resources. The astonishing ecological virtuosity of our species really is something new.

How can we explain these distinctive emergent properties of human history? Though there is broad agreement on the main mechanism that drives change in the biological realm – natural selection – there is no such consensus about the drivers of change in the human realm. There is, as yet, no “Kuhnian” paradigm for human history. Indeed, most historians resist the idea of seeking such a paradigm, and remain content to offer ad hoc explanations of particular changes. But it may be possible to do better than that, for currently several lines of argument within different disciplines seem to be converging on a single answer. I will summarize that answer as I understand it, using the idea of “collective learning” [18].¹⁸

The challenge is to explain our species’ unique ecological prowess. All living organisms are the products of evolutionary changes that allow them to procure the energy and resources they need to live and reproduce. We say they are “adapted” to a particular environment. Darwin’s great achievement was to explain, in general terms, how adaptation works through natural selection. But not all adaptation results from natural selection. Species with brains can learn new ways of adapting to their environments within a single lifetime. Individual learning is a second, and much faster adaptive mechanism than natural selection. However, its long-term impact is limited because most learning species can pass on only insignificant amounts of what they learn to other members of their species. Even species such as birds or primates that can share some information (such as bird songs), do not share enough for that knowledge to accumulate in a sustained way. We know this because sustained accumulation of ecological knowledge ought to show up in the archaeological record, as it does, uniquely, in the case of our own species. In practice, limitations on their ability to exchange learned information ensure that in all species but our own each individual has to start the learning process more or less from scratch.

We are different because we can share information with precision and in great volume through the gift of symbolic language. Strictly, of course, the difference is quantitative, but it is the sort of quantitative difference that makes a qualitative difference. Humans can exchange so much information so

¹⁸ See Michael Tomasello [27], for a similar argument, though it places less emphasis on the importance of language; Tomasello’s “cumulative cultural evolution” is close to what I call “collective learning”

precisely that, even allowing for much waste, ecologically significant information can accumulate within the memory of each community, within what anthropologists call its “culture.” We can get some feeling for how collective learning may have worked within early human communities from accounts of modern foraging societies. Richard Lee describes the chatter around a !Kung San camp in the 1960s:

The buzz of conversation is a constant background to the camp’s activities: there is an endless flow of talk about gathering, hunting, the weather, food distribution, gift giving, and scandal. No !Kung is ever at a loss for words, and often two or three people will hold forth at once in a single conversation, giving the listeners a choice of channels to tune in on [28, p.359].

At the evening camps, those who had been out hunting or gathering shared information: “... the men relate in detail the latest news of the rainfall, the ripening of fruit and of food plants, and the movements of game. Visitors arriving from other camps add to the discussion what they have observed along the way. In this manner, the members of the camp are kept fully informed about what their environment currently has to offer” [28, p.346]. As a result, the Bushmen accumulated an immense amount of useful knowledge about their environment. “This knowledge,” comments Lee, “is, in effect, a form of control over nature: it has been developed over many generations in response to every conceivable variation in climatic conditions” [28, p.361]. Over many generations, such exchanges stored useful information within large and constantly growing tribal encyclopedias of learnt knowledge. This third adaptive mechanism, which I call “collective learning,” is unique to our species, and uniquely powerful. It explains why human history moves not at the pace of genetic change but at the much faster pace of cultural change.

The results are transformative, allowing rapid, cumulative and accelerating adaptation. That is what makes our species so different. As individuals contribute what they have learned to the common stock of knowledge, that stock grows, allowing later generations to exploit their environments more effectively and sometimes to enter new environments, which adds to the stock of information available to later generations, and so on.¹⁹ This positive feedback mechanism explains the accelerating pace of change in human history which has set us apart from all other animal species. Collective learning is what distinguishes human history from the histories of all other species.

¹⁹ As Clive Gamble notes, the “tribal encyclopedias” of Paleolithic communities contained the information that enabled them, when necessary, to migrate into new environments [29, p.120].

These are large and tentative hypotheses about human history. I raise them not in the hope of convincing readers immediately of their correctness, but rather to suggest the types of research agenda suggested naturally by seeing human history as part of a single historical continuum.

4. Implications of the single historical continuum for scholarship in human history: Closer collaboration with scholars in other historically oriented disciplines will surely encourage historians to see what they can borrow from the methods, the insights, and the paradigms of other disciplines. But it will also encourage historians to explore the past on multiple scales, and doing that may introduce new types of questions into historical scholarship.

Written documents, mostly generated by the powerful or by their scribes and officials, biased historical scholarship towards the temporal and spatial scales most familiar to human actors, and placed those actors at the center of the stories historians told. This may help explain why human agency plays such a central role in most historical explanation, as well as in Collingwood's definition of the discipline. A focus on human agency highlights the unpredictability of human decisions and human whims, just as a focus on sub-atomic particles highlights the contingent nature of quantum processes.²⁰ However, once they start exploring the larger temporal scales of the single historical continuum, historians will find it both possible and necessary to explore very different types of explanations. The great French historian, Fernand Braudel, may have been anticipating just such a shift in perspective when he wrote: "... the way to study history is to view it as a long duration, as what I have called the *longue durée*. It is not the only way, but it is one which by itself can pose all the great problems of social structures, past and present. It is the only language binding history to the present, creating one indivisible whole" [31].

Historians such as Braudel have explored changes occurring at scales of decades or centuries or even, in some cases, millennia. At these scales, which are familiar to demographic and economic historians, human agency loses some of its explanatory salience, and crucial changes such as large population movements or waves of economic growth seem to occur behind the back of individual human actors. But even at these scales, human agency can sabotage the most elegant explanatory models. How can one discuss the demography of modern China without discussing the politics of the "one-child policy," or how can one discuss large economic trends of the twentieth century without

²⁰ Even many archaeologists seem more comfortable with the "quantum" perspective typical of historians. In a recent survey, Colin Renfrew writes that for most archaeologists, "The world ... is constructed through individual actions by individual people. It is a rich palimpsest, testifying to human creativity, and perhaps little more is to be expected than the collection and collation of regional narratives" [30, p.74].

mentioning Keynes or Stalin? Or, to pick an even more powerful illustration, how can one discuss world history in the thirteenth century without taking seriously the personality and the political skills of Chinggis Khan? Even at these large scales, agency often trumps structure.²¹

One reason why historians remain so attached to the notion of human agency may be that you need to shift to even larger scales before individual agency loses its salience as an explanatory factor. Indeed, you need to shift to scales that most historians would regard as outside their competence and beyond the scope of historical scholarship as traditionally understood. However, within the context of a single historical continuum it is now possible to study change at these scales, and to do so with rigor. We now have enough well-dated archaeological and paleontological evidence to make reasonable empirical generalizations about the long-term trajectory of human history since the appearance of our species, some 200,000 years ago. At this scale, the scale of human history as a whole, the large patterns stand out, just as, in the world of particle physics, we can say confidently when half of a lump of Uranium 238 will decay though we can never predict when an individual atom will decay.²² At the very large scales, even in human history, structure begins to trump agency. We see processes so large that they seem to take place behind the back of individual actors. These processes include the paleolithic migrations of our species, the long trend of increasing human numbers, the accelerating increase in human control over energy and resources, and the striking increases in social complexity since the agricultural revolution.

We also face questions that we cannot solve by studying the ideas and intentions of individual actors. Why, after living as foragers for perhaps 200,000 years, did human communities in parts of the world that had no contact with each other (such as Mesopotamia and Mesoamerica) take up agriculture within just a few thousand years of each other?²³ The puzzles get stranger with the spread of agriculture. Wherever agriculture appeared, it generated similar changes on a similar timetable. In both Afro-Eurasia and the Americas, agriculture supported numerous small sedentary communities

²¹ Peter Turchin's [32] sophisticated attempt to tease out general principles of empire building in *War and Peace and War: The Life Cycles of Imperial Nations*, illustrates some of these difficulties; the best recent biography of Chinggis Khan is Michal Biran [33].

²² The answer is in about 4.5 billion years, or roughly the age of the earth, which means that about half of the U 238 present in the early earth has since decayed

²³ The best recent survey of the origins of agriculture is Peter Bellwood [34]; note that even in Australia widespread changes in recent millennia hint at the sort of intensification that preceded the appearance of agriculture in other regions of the world. The notion of intensification was pioneered in the work of Harry Lourandos. For a survey of the debate and the evidence, see John Mulvaney and Johan Kamminga [35, chs. 14 and 15].

which expanded in range and size until some spawned towns and cities. As societies expanded, they became more complex. There appeared a division of labor, and social hierarchies organized by lineage, wealth, ethnicity and gender. Eventually, states emerged, power structures in which elites exacted tributes from farmers, artisans and traders, ruling through powerful religious and civilian bureaucracies and large armies. To manage the resources they collected, elites developed accounting systems from which the earliest writing systems evolved. (Even the Inca *quipu*, a way of recording information on knotted strings, was probably an embryonic writing system.) Everywhere, elites built monumental structures, usually in the same basic form: that of a pyramid. The transition from early agriculture to cities and states took 5-6,000 years in Mesopotamia, Egypt and parts of China; in the Americas it may have taken longer, but the broad similarities in sequence and timing are remarkable nonetheless, particularly given the near certainty that there was no significant contact between these regions.

As Colin Renfrew points out, these odd parallels “must imply some commonality both in practicality and in potential, as both are products of the human condition.”²⁴ At this scale, we are dealing with patterns of change so large that they appear to be emergent properties of human history as a whole. These patterns include the vectors I have already referred to. These, in turn, were driven by our species’ extraordinary capacity for sustained ecological innovation leading to increased control of biospheric resources. As I have suggested, that, in turn, may be a consequence of a new emergent property that distinguishes our species from all others: our capacity to keep adapting in new ways through the novel adaptive mechanism of collective learning.

In short, only when we move well beyond the 5,000 year time scale of traditional historical scholarship can we begin to see the large patterns in human history, patterns so large that we cannot explain them with the notion of individual agency. Instead, we need to look for the sort of general principles familiar within other parts of the single historical continuum: principles such as that of collective learning. These principles, in turn, raise profound questions about the way we handle historical questions at smaller scales, such as questions about the rise to dominance of particular regions of the world in different historical epochs. Why, if collective learning is so critical, should it apparently work more effectively in some eras and regions than others? Can such models help us place phenomena such as the “rise of the west” within a larger explanatory framework?

Once again, I stress that the point is not to demonstrate the correctness of the particular arguments I have offered, but to suggest the kinds of problems

²⁴ Colin Renfrew [30, p.71] points out that Robert Adams, who did pioneering work on the parallels between Mesopotamia and pre-Columban America, argued that both societies were clearly “variants of a single processual pattern.”

that become apparent at larger scales, and the explanatory possibilities that may emerge once historians start to explore the place of human history within the single historical continuum.

Conclusion: Are we on the verge of a Grand Unification of Historical Sciences?

So far I have talked about constructing a Grand Unified Story (a GUS?) embracing all parts of the single historical continuum. Is it possible to think even more ambitiously? Might it be possible, through collaborative work between all the disciplines that make up the single historical continuum, to tease out general principles of change that explain how change works across the entire continuum? Might it be possible to unify our understanding of change in the human and the biological realms just as the discovery of an “electro-weak” force unified understanding of the electromagnetic and weak forces in the early 1980s? Is it possible that, lurking behind the emerging GUS there is the historical equivalent of a GUT, a Grand Unified Theory of History?

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