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Contents

Welcome to the *Journal of Big History*

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Welcome to the first issue of the *Journal of Big History*. The International Big History Association introduces this new journal to take the most recent step towards advancing the field of big history. Beginning the journal has been seven years in the making.

In 2010, Walter Álvarez, the renowned geologist, led a seminar held at the Osservatorio Geologico di Coldigioco (Geological Observatory of Coldigioco). He brought a small group of big historians just outside of Gubio, Italy, to one of the places where there is a thin line of iridium in a mountain side. This iridium provides evidence that tells us about the end of the non-avian dinosaurs 65 million years ago and the opening for mammals to evolve into a variety of species, including humans. Back at Coldigioco, Álvarez also explained how those same mountains had greatly influenced Italian and European history and culture. He demonstrated how the human past is embedded in a much longer global and universal past.

By 2010 many scholars worldwide shared a passion for big history. Scientists, humanists, and social scientists felt a need to form a professional organization in order to structure future discussions and investigations. They recognized the importance and the difficulties of a highly interdisciplinary field whose purpose was to investigate the integrated history of the cosmos, Earth, life, and humanity, using the best available empirical evidence and scholarly methods. The outcome of the meeting in Italy was the founding of the International Big History Association (IBHA).

Plans began immediately to organize conferences where big historians could share and discuss their findings with each other. Since 2010 IBHA has organized three conferences, with a fourth scheduled for 2018, and has published a regular bulletin. These initiatives aimed at developing the still new field of big history.

In the 1970's scholars from many disciplines began piecing together an evidence-based narrative that began – as best as we know now – 13.8 billion years ago. We are able to trace this account from almost immediately after the big bang, to the emergence of protons and neutrons each from three quarks, the formation of hydrogen and helium atoms 380,000 years later, the first stars and galaxies, the formation of chemicals, supernovae, the accretion of Earth 4.5672 billion years ago, the first living organisms within a few hundred million years of that, the great increase in complexity of life forms, the eventual evolution of humans about 200,000 years ago, and the development of increasingly complex social, economic, and political cultures over the past 12,000 years. On this evidence we can project possible scenarios of the future.

No one person could possibly master all the fields necessary to produce this achievement. Only by working together, learning from each other, and building on earlier work could scholars from many disciplines start to connect the dots among the disciplines.

Universities have long been dedicated to the pursuit of a universe of knowledge. Yet the many disciplines that exist within universities and the many subfields that exist in each discipline do not yet all fit together neatly. Often a discipline, or a subfield, tries to build impenetrable walls around itself, protecting its own isolation, and budget lines. Academic silos are sometimes as resistant to forming connections with each other as protons are to each other in the absence of sufficient pressure.

Still, some scholars continue to forge intellectual relationships and build a coherent account of the entire known past. Marcelo Gleiser, professor of physics and astronomy at Dartmouth College, uses the analogy of a painstakingly constructed island of knowledge whose shoreline borders on what we do not yet know or understand. The analogy brings to mind the island continent of Australia, where the new field was named by David Christian at Macquarie University a quarter of a century ago.

Gleiser's analogy of an island of knowledge includes the efforts by many people to increase the size of the island by making intellectual advances. The human island of knowledge has increased over the past millennia, centuries, decades, and years. With this in mind, it is fitting that one of the main centers of big history has been at the University of Amsterdam in the Netherlands, with its history of forming its own land from the sea beyond itself through the ingenuity and effort of its own people.

Rather than providing the intellectual vision for a single island of knowledge, universities are sometimes sites for largely separate disciplines and departments. Each scholar lives on one of a number of islands that are barely within sight of each other. The expertise of disciplines and intellectual focus on specific issues are without doubt highly valuable. They have produced the data from which big history has emerged. Each discipline offers its own sets of analyses and understandings. But by themselves, none of them could construct the comprehensive narrative that they can together. Filling in the spaces between the islands of knowledge, connecting each of them, and pushing out their borders into the unknown, are no easy tasks. Developing big history requires both advances within established disciplines and intellectual synthesis.

With each new addition to the island of knowledge, with each answer found, with each improvement to our understanding, new questions are raised. We become even more aware of what we still do not know. To push out our borders and to build the connections among our various islands, we will need to address many still unanswered questions. Just a very few of these might include: How did the universe begin when it did? Can we find evidence for other universes, or fundamentally different kinds of reality than exist in this universe? What is nature if we cannot observe formative parts of it without that observation changing them? What do the smallest components of our own universe tell us about the nature from which we have emerged and that sustains us for now? Exactly how did life originate?

How can we connect what we do know to provide a better account of where we have come from and who we are now? Why does complexity sometimes develop, while often it does not? Some of the hydrogen and helium that floated in unimaginably huge clouds soon after the Big Bang became stars, Earth, single cells, mammals, and finally us. The 100 billion neurons with their trillion synapses make each of our brains the most complex matter in the universe of which we know. But huge clouds of the simplest elements remain. Unimaginable numbers of single cell organisms continue to survive perfectly well without any increase in their structural complexity.

Our complex brains have permitted – and have been stimulated by – the increasingly complex relationships among humans in kinship groups, villages, cities, empires and nations, and global or human structures. Yet, earlier and simpler compositions often continue, and more complex ones often return to simpler ones. In recent times, we have seen regional and global networks being challenged by populist ones which exhibit properties that sometimes seem similar to tribal ones. Our ideas of what it means to be human within our many sub-categories may have as many layers and components as the rest of nature from which we have evolved.

We – and the rest of nature – remain an unfinished puzzle. Our over-arching narrative has many gaps and questions. Much remains to investigate and ponder, share and debate. The more we know and understand, the more we butt up against what we do not know and wake up at night trying to figure out.

The *Journal of Big History* appears as the result of cooperation by many people. Long discussions early on among David Baker, Cynthia Brown, David Christian, Andrey Korotayev, Esther Quaedackers, Barry Rodrigue, Fred Spier, and the late Ji-Hyung Cho, provided the foundation for the subsequent proposal for a journal that was discussed, developed, and approved in 2016 by the IBHA Board of Directors.

Heathe Kyle Yeakley has generously offered much technical advice and service. We have depended on the careful work of many reviewers and the journal's editorial board. The ideas, careful editing, and commitment of Esther Quaedackers and Cynthia Brown to every stage of producing the journal are indispensable. The scholarship of all those who submit manuscripts is the key to the success of the journal.

The IBHA will continue to organize conferences that will encourage traditional and innovative approaches to big history. It will continue to present provocative pieces in its bulletin, *Origins*. And now, it introduces this new journal to advance the field of big history.

Welcome to the shoreline of the islands where we live now. In this journal we will seek to cultivate each island of evidence-based knowledge, fill in the open spaces between them, and maybe expand our shoreline from time to time.

Note to Contributors

In this journal, we seek to share new scholarship about big history. Please submit your manuscripts to Lowell Gustafson at jbh@ibhanet.com or at journalofbighistory.org. Manuscripts will go through a double blind review in which submitters and reviewers will not be informed of each others' names. Articles should be approximately 10,000 words in length, readable by scholars across disciplines, and based on evidenced and logical thinking. Please use the Chicago manual of style where possible, but in our highly interdisciplinary field, you may use styles that are traditional in your disciplines.

Books to be reviewed may be sent to Cynthia Brown, 139 Stonewall Road, Berkeley, CA 94705. Book reviews should be sent to Cynthia S. Brown (cbcynthia@earthlink.net) and John Mears (jmears@mail.smu.edu).

What is Big History?

David Christian
Distinguished Professor and Director of the Big History Institute
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> As they err who study the maps of regions before they have learned accurately the relation of the whole universe and the separate parts of it to each other and to the whole, so they are not less mistaken who think they can understand particular histories before they have judged the order and sequence of universal history and of all times, set forth as it were in a table.[1]

Big history represents an attempt at what E.O. Wilson has called "consilience," a return to the goal of a unified understanding of reality, in place of the fragmented visions that dominate modern education and scholarship.[2] Though it may seem new, the goal of consilience is very old. And even in its modern forms, big history has been around for at least a quarter of a century. So the publication of the first issue of the *Journal of Big History* provides the ideal opportunity for a stock take.

This article is a personal account of the field. It sees big history as the modern form of an ancient project. I am a historian by training, so my account focuses on the relationship of big history to the discipline of history. It reflects the perspective of a historian trained in the English-speaking world, and it focuses on big history's relationship to Anglophone historical scholarship. But not *just* to Anglophone historical scholarship, because the debates I discuss had their counterparts and echoes in many other traditions of historical scholarship. Nor do I focus just on historical scholarship as it is normally understood within the academy, because big history sees human history as part of a much larger past that includes the pasts studied by biologists, paleontologists, geologists and cosmologists. By linking different perspectives and scales, and many different scholarly disciplines, all of which try to understand the deep roots of today's world, big history can transform our understanding of "history."

However, to fully capture the richness and range of this vibrant new field of research, scholarship and teaching, we will eventually need the perspectives of big historians trained in many other disciplines. I hope this essay may encourage such scholars to offer their distinctive perspectives on big history.

The evolution of historical scholarship in the twentieth century

Historians will recognize that my title comes from a classic essay on history, studied by most Anglophone history graduates. It was written in 1961 by E.H. Carr, an English historian of the Soviet Union. Carr's book began as a lecture series given at Cambridge in 1961 in honor of George Macauley Trevelyan, a historian who, unlike Carr, saw history as a literary discipline, and quite distinct from the sciences. As a historian of Russia and the Soviet Union, Carr took seriously the Marxist insistence that history should be regarded as a branch of science, and that idea influenced my own thinking about history as I, too, entered the field of Russian history as a graduate student in the early 1970s.

In "What is History?" Carr tracks the evolution of the history discipline in England in the early 20th century. At one level, his story is of a sustained trend away from the confident realism, positivism

1 Jean Bodin, 16th century, cited from Craig Benjamin "Beginnings and Endings," in Marnie Hughes-Warrington, ed., *Palgrave Advances in World Histories* (New York: Palgrave Macmillan, 2005). 95.
2 E.O. Wilson, *Consilience: The Unity of Knowledge* (London: Abacus, 1998).

and even universalism of many nineteenth century historical thinkers, towards increasing fragmentation and skepticism. He begins by citing Lord Acton's confident vision of historical scholarship from the 1890s, as Acton presided over the first edition of the *Cambridge Modern History.* Acton saw the *Cambridge Modern History* as "a unique opportunity of recording, … the fullness of the knowledge which the nineteenth century is about to bequeath…." He added: "Ultimate history we cannot have in this generation [but] … all information is now within reach, and every problem has become capable of solution."[3] Acton's view of history is confident, positivist, and optimistic, and it assumes that history is part of the larger project of increasing human knowledge in general. His vision of history is also broad. He assumed that historians should aim at some kind of "universal history," though he seems to have understood that phrase to mean, not an early form of big history, but something closer to modern "world history" or "global history." Acton defined universal history as "that which is distinct from the combined history of all countries."[4]

In the early twentieth century, English historical scholarship underwent a profound transformation, and when Carr wrote, the discipline was more fractured and less sure of itself. These shifts were part of a sea-change that affected most scholarly disciplines, from the humanities to the natural sciences, as specialization and professionalization broke scholarship into ever-smaller compartments, each offering its own pin-hole view of the world. Specialization proved a powerful research strategy, but it was achieved by severing ancient links among fields of knowledge, leaving them increasingly isolated from each other. The idea of a single world of knowledge, whether united by religious cosmologies, such as that of Christianity, or by scientific scholarship—the vision that lay behind Alexander von Humboldt's attempt to write a scientific universal history in his *Kosmos*—was abandoned.[5] In humanities disciplines such as history, which lacked the sort of unifying paradigm ideas characteristic of the natural sciences in the era of Darwin, of Maxwell and of Einstein, specialization also undermined Acton's confident epistemological realism.[6]

Carr captures some of these changes by citing the introduction to the second edition of the *Cambridge Modern History,* written by George Clark in 1957, more than half a century after Acton's confident pronouncements. After citing Acton's hopes for an "ultimate history," Clark writes:

> Historians of a later generation do not look forward to any such prospect. They expect their work to be superseded again and again. …The exploration seems to be endless, and some impatient scholars take refuge in skepticism, or at least in the doctrine that, since all historical judgements involve persons and points of view, one is as good as another and there is no 'objective' historical truth.[7]

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3 E. H. Carr, *What is History?* (Harmondsworth: Penguin, 1964), 7. 1st published in 1961, based on the George Macaulay Trevelyan Lectures, delivered in 1961 in Cambridge.

4 Carr, *What is History?* 150.

5 On Humboldt as a big historian before his time, see Fred Spier, *Big History and the Future of Humanity,* 2nd ed. (Malden, Mass.: Wiley Blackwell, 2015, 18-21, and Andrea Wulf, *The Invention of Nature: The Adventures of Alexander von Humboldt, the Lost Hero of Science*, (London: John Murray, 2015).

6 The distinction between paradigm and pre-paradigm disciplines was introduced by a book whose first edition appeared in 1962, just a year after Carr's book: Thomas Kuhn, *The Structure of Scientific Revolutions,* 2nd ed. (Chicago: University of Chicago Press, 1970).

7 Carr, *What is History?* 7-8.

The loss of confidence in a realist or naturalist epistemology in disciplines such as history, widened the gulf between the "two cultures" of the sciences and humanities that so worried C.P. Snow in a famous lecture delivered in 1959.[8] The gulf was particularly wide in the English-speaking world, because English, unlike most other scholarly languages, confined the word, "science," to the natural sciences. In English, the very idea of "historical science" began to seem absurd. By Carr's time, historical scholarship had lost confidence both in the "scientific" nature of historical scholarship, and in the realist epistemology that still underpinned research in the natural sciences.

Skepticism and intellectual fragmentation sapped confidence in the value of historical research, and undermined the ancient hope that history could empower us by helping us better understand the present. As historians became increasingly isolated from other disciplines and even from each other, they were left with increasingly fragmented visions of the past, and of the nature and goals of history. This growing sense of fragmentation was the scholarly counterpart of what Durkheim called *anomie*, the loss of a sense of coherence and meaning, an idea that Carr himself glosses in a footnote as "the condition of the individual isolated from … society."[9] Scholarly *anomie* arose from the growing isolation of scholars both from each other and from a unified world of knowledge. The one force that partially mitigated the growing sense of scholarly isolation was nationalism. Though tribal by their very nature, national histories, which had flourished since the nineteenth century, provided some sense of cohesion for historians working within national historiographical traditions.

Carr's own position falls between the robust scientific realism of Acton and the hesitant relativism of Clark. He explores brilliantly the complex dialectic between history as truth and history as stories we tell about the past. He takes truth and science seriously, because he believes that history, like science, and like truth in general, has a purpose: it can empower us. It empowers us by improving our understanding of the present, and it does that by mapping the present on to the past: "The function of the historian is neither to love the past nor to emancipate himself from the past, but to master and understand it as the key to the understanding of the present."[10] It followed that the maps of the past created by historians had to be good maps. Like good science, they had to give us a better grip on the real world. So Carr, like Marx, was a philosophical realist and saw no fundamental chasm between the humanities and the natural sciences. "Scientists, social scientists, and historians are all engaged in different branches of the same study: the study of man and his environment, of the effects of man on his environment and of his environment on man. The object of the study is the same: to increase man's understanding of, and mastery over, his environment."[11]

On the other hand, Carr understood more clearly than Acton that the past is not simply waiting to be discovered, "like fish on a fishmonger's slab."[12] History consists of stories about the past constructed by historians, and how we construct those stories changes as our world and our purposes change. We need empirical rigor to get at the truth about the past, but when telling *stories* about the past we will need the skills of storytellers, including what Carr calls "imaginative understanding," the ability to understand and

8 C. P. Snow, *The Two Cultures and the Scientific Revolution* (Cambridge: Cambridge University Press, 1959).
9 Carr, *What is History?* 32.
10 Carr, *What is History?* 26.
11 Carr, *What is History?* 84.
12 Carr, *What is History?* 23.

empathize with those who lived in the past.[13] In this, Carr was influenced by one of the great English philosophers of history, R.G. Collingwood, though he warned that Collingwood's emphasis on the empathetic role of the historian, if taken too far, could lead to extreme skepticism.[14]

Particularly influential on Carr's thinking was Marx's dialectical balance between science and activism. Marx insisted that there is an objective past. But making something of that past is a creative task, and how we approach it depends on who we are and the particular present in which we write and study. This is the dialectic that Marx described in a famous passage from the "18th Brumaire of Louis Napoleon."

> Men make their own history, but they do not make it just as they please; they do not make it under circumstances chosen by themselves, but under circumstances directly found, given and transmitted from the past. The tradition of all the dead generations weighs like a nightmare on the brain of the living.[15]

Historians, too, "make their own history," but they do so "under circumstances directly found, given and transmitted from the past." What they make of the past depends on the time and place in which they write. But the stories they construct about the past may, in their turn, influence the pasts studied by future historians. As an activist, Marx understood well that *how* we describe the past matters, because our accounts may shape the future. Indeed, he hoped that his own account of the evolution of capitalism would have a profound impact on the future, as indeed, it did.

Like Marx, then, Carr understood the complex and delicate balance between history as truth and history as story. History is, Carr wrote, in a passage familiar to many a graduate student in history: "a continuous process of interaction between the historian and [the] facts, an unending dialogue between the present and the past."[16] Like memory, history does not *recall* the past; it *re-creates* it.

But what past? Carr was even more committed than Acton to broadening the scope of historical research. He was, after all, a historian of Russia, and keen to demonstrate the significance of histories that had been neglected by English-speaking historians. As an admirer of Joseph Needham, he also insisted on the importance of Chinese history and the histories of many other parts of the world beyond Europe.

But, though Carr's past is broad, it is not deep. He shows little interest in human prehistory or in the histories of the biosphere and the Universe. And that is surprising, given his interest in Marx, who saw history as part of a knowledge continuum that included all the sciences. Indeed, Marx, like von Humboldt, was a big historian before his time. But Carr wrote in an era of scholarly fragmentation, and the idea of universal history was not on his radar, or on the radar of any English-language historians of his generation. Strangely, though, it *was* on the radar of historians in the Soviet Union, the country whose history Carr wrote most about, because the Soviet Union's Marxist heritage ensured that the idea of "universal" or "general" history never entirely lost its inclusive Marxist sense. That is one reason why, today, there is a flourishing Russian school of big history research led by scholars such as Andrey Korotayev and Leonid Grinin.

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13 Carr, *What is History?* 24.

14 Collingwood's work, like Carr's, was staple fare for graduates of my generation. His most important work was R. G. Collingwood, *The Idea of History*, rev. ed., Jan Van der Dussen (Oxford and New York: Oxford University Press, 1994).

15 Cited from Robert C. Tucker, ed., *The Marx-Engels Reader*, 2nd ed. (New York and London: W.W. Norton & Co., 1978), 595.

16 Carr, *What is History?* 30.

In 2001, David Cannadine edited a collection of essays called *What is History Now?* based on a conference held to mark the 40th anniversary of Carr's book.[17] Much had changed since Carr wrote. The history discipline had become even more fragmented, in both content and epistemology, and even less sure of itself. The universalist vision of Marx or von Humboldt or H.G. Wells seemed to have vanished completely, surviving only in the cut-down version of national histories. Many of the changes evident in Cannadine's collection reflect the post-war proliferation of universities, university students, historians, and historical sub-disciplines. This was a worldwide phenomenon, so similar trends can be found, with variations, in many different historiographical traditions.

Since Cannadine's book was no longer about a single history discipline, it was appropriate that it had multiple authors. More historians and more students seemed to mean more diverse ideas on the content, the meaning and the purpose of historical scholarship. Each chapter is about a different type of history, so there are chapters called: "What is Social History now?" "What is intellectual History Now?" and "What is Cultural History Now?" The absence of "What is Women's History Now?" or "What is Environmental History Now?" is striking, though Cannadine insists that his book reflects just a small number of the sub-disciplines into which history was then divided.

Fragmentation was accompanied by increasing skepticism about the objectivity and the scientific nature of the discipline. True, most historians continued to approach the details of their research with a robust, realist empiricism, so much so, that many caricatured the discipline as just a catalogue of facts. But, as the circle of questions widened, the confidence of historians seemed to dwindle, and few were comfortable with the idea of historical scholarship as part of a larger system of knowledge or meaning. Historians became increasingly isolated from other disciplines (the decline of economic history is a striking example of this process), and even from each other, and any consensus about the nature and goals of history seemed to evaporate. In an introductory essay to Cannadine's book, Richard Evans noted the increasing focus in a postmodernist era on the creative and subjective role of the historian and on the historian's role as storyteller. This approach had been epitomized in Hayden White's 1973 classic, *Metahistory: The Historical Imagination in Nineteenth Century Europe,* which focused almost entirely on the literary aspects of historical scholarship, rather than on the truth claims it made. Historical scholarship seemed to have splintered into multiple, incommensurable, stories about the past, each representing a particular perspective, and none confident about its claims on historical truth. Historians seemed to have taken on the deep skepticism towards grand narratives or meta-narratives that Jean- François Lyotard saw as a defining feature of postmodern thought.[18]

And yet, … though the tremors barely registered on the seismograph of Cannadine's volume, by the year 2000, the idea of a new form of universal history was already rattling the margins of historical scholarship. World history was flourishing in the USA, had a well-established scholarly organization and a successful journal (*The Journal of World History*), and was taught in an increasing number of universities and schools. But several scholars now ventured far beyond world history. They began to explore the possibility of a truly universal history that would embrace the whole of the past, including the pasts of the biosphere and the entire universe. By 2001, I had been teaching big history for 12 years, but I was just one member of a small but vigorous community of scholars moving in the

17 David Cannadine, ed., *What is History Now?* (Basingstoke: Palgrave/Macmillan, 2002).

18 Jean-François Lyotard, *The Postmodern Condition: A Report on Knowledge*, trans. Geoff Bennington and Brian Massumi (Minneapolis: University of Minnesota Press, 1984).

same direction. Eric Chaisson had been teaching astronomer's versions of big history for more than twenty years, and big history was being taught in Amsterdam by Fred Spier and Johan Goudsblom, in Dallas by John Mears, in San Rafael by Cynthia Stokes Brown, in Melbourne by Tom Griffiths and Graeme Davidson, and elsewhere. Big history snuck up on a history discipline that was looking in the opposite direction.

Today, fifteen years after Cannadine's volume, big history remains marginal, but it is beginning to shake up the history discipline.[19] There is an emerging scholarly literature that proves big history can be written with rigor and precision and can yield new, sometimes transformative, insights into the past.[20] Big history is being taught successfully in several universities, mostly in the English-speaking world, and even those history departments that do not teach it often include discussions of big history in their historiography seminars. There are several MOOCs (Massive Open Online Courses) on big history. There is a scholarly association (the IBHA), which has held three major conferences, and now there is a journal of big history. Macquarie University has established a Big History Institute, which has organized two research conferences. Big history is even being taught in hundreds of high schools, mostly in the USA and Australia, through the "Big History Project," a free, on-line high school syllabus in big history, launched in 2011 and funded by Bill Gates.

What seemed just decades ago an archaic, unrealistic, and perverse approach to historical scholarship is now beginning to look like a powerful, rigorous and even transformative form of modern scholarship, which can re-connect historical scholarship and teaching to other disciplines in both the humanities and the sciences.

Why the return to Universal History?

What happened?

Some of the crucial changes occurred within the history discipline itself. There had always been a few scholars, such as H.G. Wells or Arnold Toynbee, who kept alive the vision of a more capacious understanding of the past. But specialist research also laid the foundations for a broader view of the past, by generating a colossal amount of new historical scholarship and tackling subjects and regions and epochs that had been ignored by earlier generations of historians. Felipe Fernandez-Armesto, a world historian with extraordinarily broad interests, puts it nicely in a chapter in Cannadine's volume:

> Historians dig ever deeper, narrower furrows in ever more desiccated soil until the furrows collapse and they are buried under their own aridity. Yet on the other hand, whenever one climbs out of one's furrow, there is now so much more of the field to survey, so much enriching new work, which can change

19 One interesting example is *The History Manifesto,* by Jo Guldi and David Armitage, (Cambridge: CUP, 2014), which offers an aggressive critique of short-termism in contemporary historical scholarship.

20 A start up list might include Eric Chaisson, *Cosmic Evolution: The Rise of Complexity in Nature,* Cambridge, MA: Harvard University Press, 2001; David Christian, *Maps of Time: An Introduction to Big History,* Berkeley, CA: University of California Press, 2nd ed., 2011; Fred Spier, *Big History and the Future of Humanity,* 2nd ed., Malden, MA: Wiley/Blackwell, 2015; Cynthia Stokes Brown, *Big History: From the Big Bang to the Present,* 2nd ed., New York: New Press, 2012; a university text, David Christian, Cynthia Stokes Brown, and Craig Benjamin, *Big History: Between Nothing and Everything,* New York: McGraw-Hill, 2014; anthologies of essays, such as Barry Rodrique, Leonid Grinin and Andrey Korotayev, eds., *From Big Bang to Galactic Civilizations: A Big History Anthology,* Vol. 1, *Our Place in the Univere,* Delhi: Primus Books, 2015; and a beautifully illustrated overview, Macquarie University Big History Institute, *Big History,* London: DK books, 2016.

> one's perspective or broaden one's framework of comparison.[21]

However, many of the changes that allowed a return to universal history occurred beyond the history discipline, and particularly within the natural sciences, which had always been more friendly than the humanities to the idea of consilience.[22] The quantum physicist, Erwin Schrödinger, had already anticipated new forms of scholarly unification in a book he wrote just after World War II on the nature of life.

> We have inherited from our forefathers the keen longing for unified, all-embracing knowledge. The very name given to the highest institutions of learning reminds us that from antiquity and throughout many centuries the universal aspect has been the only one to be given full credit. … We feel clearly that we are only now beginning to acquire reliable material for welding together the sum total of all that is known into a whole; …[23]

In the natural sciences, as in the humanities, specialized scholarship over many decades yielded a huge bounty of new information and ideas. Equally important was the emergence of new unifying paradigm ideas. The most important were Big Bang cosmology, plate tectonics and the modern Darwinian synthesis. The new paradigms were barely visible when Carr wrote. DNA had been discovered in Carr's own University of Cambridge, in 1953, but the full significance of that discovery would only become apparent over the next decade or two. The discoveries that clinched plate tectonics and Big Bang cosmology still lay a few years in the future. By 1970, though, the new paradigms were already encouraging hopes of a new unification of knowledge, at least in the natural sciences. Some scientists began to talk of "Grand Unified Theories."

Particularly striking is the fact that the new scientific paradigms were historical in nature. Gone was the static universe of Newton, replaced by a universe that operated according to historical and evolutionary rules. E.H. Carr was aware of the "historical turn" in the natural sciences, and its significance for history, though his insights would be ignored by most historians over the next fifty years or so. Science, he wrote:

> had undergone a profound revolution …. What Lyell did for geology and Darwin for biology has now been done for astronomy, which has become a science of how the universe came to be what it is …. The historian has some excuse for feeling himself more at home in the world of science today than he could have done a hundred years ago.[24]

In the English-speaking world, Big Bang cosmology encouraged astronomers such as Carl Sagan to recount the history of the universe, while plate tectonics encouraged geologists such as Preston Cloud to write new histories of planet earth.[25] It turned out that many natural scientists were in the same messy business

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21 Cannadine, ed., *What is History Now?* 149.

22 This section summarizes and adds to arguments I have presented in "The Return of Universal History," *History and Theory*, Theme Issue, 49 (December, 2010), 5-26.

23 Erwin Schrödinger, *What is Life?* (Cambridge: CUP, 2000), 1 [first pub. 1944]; Schrödinger was also acutely aware of the barriers that specialization placed in the way of such ambitions.

24 Carr, *What is History?* 57.

25 Carl Sagan's television series, *Cosmos,* was first broadcast in 1980; Preston Cloud's *Cosmos, Earth, and Man: A Short History of the Universe* (New Haven: Yale University Press, 1978) was published just two years earlier; the Soviet Union already had a flourishing tradition of "biosphere" history, pioneered by the great geologist, Vladimir Vernadsky in works such as V. I. Vernadsky, *The Biosphere,* New York: Springer-Verlag, 1998.

as historians—that of trying to reconstruct a vanished past from the random clues it had left to the present. The historical turn in the natural sciences brought the methods of scientists closer to those of historians. Controlled experiments on the origins of life on Earth or the Russian Revolution were out of the question. Instead, it turned out that many scientific disciplines faced the same methodological challenge as historians: that of collecting as many clues to the past as they could—from ancient starlight, to zircon crystals, to fossil trilobites—and using them to reconstruct plausible and even meaningful accounts of the past. This was territory familiar to historians. The knockdown dis-proofs favored by Karl Popper were rarely available, and other, fuzzier, skills familiar to historians, such as pattern-recognition or hunches bases on prolonged familiarity with a given field, acquired increasing salience in the natural sciences.[26]

Particularly important for the emergence of modern forms of universal history was the development of radiometric dating techniques that could provide a firm chronological skeleton for histories of the deep past.[27] When H.G. Wells attempted a universal history just after World War I, the early parts of his story sagged because, as Wells admitted, all his absolute dates depended on written records, so he could provide none before the First Olympiad (776 BCE).[28] Nineteenth century geologists had learned how to construct relative chronologies by studying the layering of ancient rocks, but none could tell when the Cambrian explosion occurred or when Earth formed.

This all changed with the emergence of radiometric dating techniques in the 1950s. In 1953, Claire Paterson used the half-life of uranium in meteorites to determine that Earth is 4.56 billion years old. His date stands to this day. When Carr wrote in 1961, radiometric dating was just beginning to transform the thinking of archaeologists and pre-historians. In 1962, at Kenniff Cave in South Queensland, John Mulvaney used radiometric techniques to show that humans had lived in Australia since before the end of the last ice age, and over the next few decades, the earliest dates for human settlement in Australia would be pushed back to between 50,000 and perhaps 60,000 years.[29] As Colin Renfrew writes:

> … the development of radiometric dating methods, … allowed the construction of a chronology for prehistory in every part of the world. It was, moreover, a chronology free of any assumptions about cultural developments or relationships, and it could be applied as well to nonliterate societies as to those with written records. To be prehistoric no longer meant to be ahistoric in a chronological sense.[30]

Eventually, radiometric and other dating techniques made it possible to construct rigorous chronologies reaching back to the origins of the universe. For the first time, it is now possible to tell a universal history based on a robust universal chronology.

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26 There is a fine account of the real, as opposed to the idealized, methodologies of modern science in John Ziman, *Real Science: What it is, and what it means* (Cambridge: CUP, 2000).

27 See David Christian, "Historia, complejidad y revolución cronométrica" ["History, Complexity and the Chronometric Revolution"], *Revista de Occidente*, Abril 2008, No 323, 27-57, and David Christian, "History and Science after the Chronometric Revolution", in Steven J. Dick and Mark L. Lupisella, eds., *Cosmos & Culture: Cultural Evolution in a Cosmic Context* (NASA, 2009), 441-462; and see Doug Macdougall *Natures' Clocks: How Scientists Measure the Age of Almost Everything* (Berkeley: University of California Press, 2008).

28 H.G. Wells, *Outline of History: Being a Plain History of Life and Mankind*, 3rd ed., (New York: Macmillan),1921, 1102.

29 John Mulvaney & Johan Kamminga, *Prehistory of Australia* (Sydney: Allen & Unwin, 1999), 1-2.

30 Colin Renfrew, *Prehistory: The Making of the Human Mind* (London: Weidenfeld and Nicolson, 2007), 41.

Some of these changes did just register in David Cannadine's collection of essays. In the last chapter of that book, Felipe Fernandez-Armesto argued that history had widened its scope, specialization by specialization, and now needed to embrace the natural sciences: "history can no longer remain encamped in one of 'two cultures'. Human beings are obviously part of the animal continuum."[31] In 1998, the great world historian, William H. McNeill, argued that historians needed to embed the history of humanity within the history of the biosphere and even the Universe as a whole:

> Human beings, it appears, do indeed belong in the universe and share its unstable, evolving character.... [W]hat happens among human beings and what happens among the stars looks to be part of a grand, evolving story featuring spontaneous emergence of complexity that generates new sorts of behavior at every level of organization from the minutest quarks and leptons to the galaxies, from long carbon chains to living organisms and the biosphere, and from the biosphere to the symbolic universes of meaning within which human beings live and labor, …[32]

In his last years, McNeill became increasingly interested in the idea of Big History, seeing it as a natural extension of his own broad vision of history. It was, as his son, John, has written: "the thing that excited him most (aside from grandchildren)."[33]

What is Big History?

So, what is big history?

In the final part of this essay I would like to explore several, overlapping descriptions of what big history is and what it could be. These are personal thoughts, and some are speculative. But I hope they may interest even those who are less persuaded by them than I am. And I hope they may encourage a broad discussion about big history and its future. My thoughts are organized, loosely, along a spectrum running from the 'truth' end of Carr's dialectic of history towards the 'storytelling' end.

The goal of big history, like that of all good knowledge, is to empower us by helping us understand the world we live in. Big history empowers us by helping us understand our world. Like all forms of history, big history empowers us primarily by mapping the present onto the past, so as to help us better understand how today's world came to be as it is. This claim about the purpose of history assumes a realist or naturalist understanding of knowledge. As evolved creatures, we interact with our surroundings with some degree of success, and that success presupposes that we (like all living organisms) can attain a limited but real understanding of our surroundings. Though aware of the limits to knowledge, big history, like science in general, resists extreme forms of skepticism or relativism. It builds on the same realist and naturalist foundations as good science, and has the same ultimate goal, of empowerment.

Big history is universal. But if understanding the past can empower us, shouldn't we try to understand the *whole* of the past? What distinguishes big history most decisively from other forms of historical scholarship is its attempt to understand the past *as a whole.* It aspires to a universal understanding of history. Big history is not hostile to specialist historical scholarship. On the contrary, it is utterly dependent on the rich

31 Cannadine, *What is History Now?* 153.
32 William H. McNeill, "History and the Scientific Worldview," *History and Theory,* 37, no. 1 (1998): 12-13.
33 *Origins* (Newsletter of the International Big History Association)*,* VI.08 (2016), 7.

scholarship of specialists. But it tries to link the findings of specialist scholarship into a larger unifying vision, just as millions of local maps can be connected to form a single world map. These ambitious goals mean that big history swims against the tide of intellectual fragmentation that structured so much scholarship in the twentieth century. Big history aims at consilience, at what Alexander von Humboldt once called the "Mad Frenzy … of representing in a single work the whole material world."[34]

Many interesting consequences flow from big history's ambitious universalism. Big history recognizes no disciplinary barriers to historical knowledge. It presumes the existence of a whole range of historically-oriented disciplines, all of them linked by the same goal: that of reconstructing how our world came to be as it is. Indeed, I often wonder if we may not see, sometime in the future, a re-arrangement of university campuses, so that, instead of putting the sciences at one end and the humanities at the other, you would find a zone devoted to 'the historical sciences', in which astronomers, geologists, evolutionary biologists, neuroscientists, and historians would all be working together.

The universal aspirations of big history mean that it will embrace all areas of knowledge that have generated plausible, rigorous, evidence-based accounts of the past, and any discipline whose insights can illuminate the past. This means that, at present, it makes sense to draw a line between everything that happened just after the big bang—a past that can be reconstructed with oodles of evidence—and anything that preceded the big bang, territory where there is plenty of interesting speculation, but not, as yet, a taut, evidence-based story. This may change, of course, in which case, the big history story itself will expand to incorporate, perhaps, evidence for a multiverse or for string theory. Similar changes may occur in other parts of the big history story, as biologists probe the origins of life on earth, or astronomers look for life around other star systems, or as neuroscientists and psychologists begin to get a grip on the 'hard' problem of consciousness, or historians get a better understanding of the role of religion and science in human history at multiple scales.

With these qualifications, big history aims at a comprehensive understanding of history, the intellectual equivalent of a world map of the past. Like a world map, the big history story can help us see not just the major nations and oceans of the past, but also the links and synergies that connect different scholarly continents, regions and islands into a single knowledge world. The broad perspective of big history also encourages us to move among multiple scales, from those of the universe itself, to those of humans, to those of individual cells, within which millions of precisely calibrated reactions occur every second. Big history encourages us to connect the dots in time and space, to look for the synergies between disparate entities, disciplines and scales. Russian scholars such as Andrey Korotayev have been particularly active in the important task of looking for mathematical patterns in the evolution of complexity at multiple scales.

By focusing on the ideas that link disciplines, big history can help us overcome the more extreme forms of skepticism characteristic of much twentieth century scholarship, particularly in the humanities. In Durkheim's hands, the idea of "anomie" referred to the absence of a clear sense of place or meaning, a condition of intellectual homelessness in which the world itself made little sense and individuals could feel isolated enough to contemplate suicide. The extreme fragmentation of twentieth century scholarship allowed great intellectual progress, discipline by discipline. But it did so at the cost of isolating disciplines from each other, which limited the possibilities

34 Andrea Wulf, *The Invention of Nature*, Chapter 18, "Humboldt's *Cosmos.*"

both for a larger, unifying vision, and for truth-checking between disciplines. Particularly in the humanities, intellectual isolation generated scholarly forms of anomie that sapped confidence in claims to generate meaning or to achieve a more general grasp of reality. The postmodernist skepticism shared by so many scholars in the humanities in the late twentieth century was a useful corrective to over-confident forms of positivism. But, when taken to extremes, it created a splintered sense of reality that could be profoundly *dis*-empowering, both intellectually and ethically. Some saw it as the scholarly equivalent of suicide.

Big history returns, with due scientific modesty, to the ancient project of trying to assemble unified maps of reality. By removing the partitions between disciplines, big history can help re-establish a more balanced relationship between specialist scholarship and large, paradigm ideas.

Big history is collaborative and collective. The big history story is being assembled, like a vast mosaic, using tiles from many different countries, epochs and scholarly disciplines. All scholarship is collaborative. But the extraordinary range of big history puts collaboration at the heart of the new discipline. A rich and reliable big history story will not be the product of individual scholarly minds, but the joint creation of millions of minds.

The extreme scholarly collaboration required to write big history should encourage a re-think of what we mean by expertise. Specialization encouraged the notion that, if you narrowed the field of enquiry enough, individual scholars could achieve total mastery of a field. They became experts. This view was always naïve because even the narrowest of experts drew on insights and paradigms from outside their fields of expertise. But the extraordinary breadth of big history means that, though it will build on the insights of experts, it will also require many other scholarly skills, not all of which are valued in today's fragmented knowledge world. Big history requires, above all, an ability to grasp and then link scholarship from many different disciplines. It demands breadth as much as depth, and a sharp eye for unexpected synergies among disciplines. And it requires an ability to tune into the different intellectual frequencies of multiple disciplines. Big historians will have to be interdisciplinary translators, sensitive to subtle nuances in the way different disciplines use similar concepts, words and methods. And they will also ask deep interdisciplinary questions. Are there ideas that work well across multiple disciplines, from cosmology to biology and history, ideas such as the "regimes" and "Goldilocks conditions" described by Fred Spier, or the "free energy density" rates that lie at the heart of Eric Chaisson's work? Can the idea of entropy, which plays such a powerful role in physics, illuminate our understanding of human history? Can the atomic level molecular machines being explored today by nano-biologists suggest new ways of managing energy flows in today's world?[35] Are there universal mechanisms (perhaps some form of universal Darwinism?) that explain the appearance of increasingly complex entities despite the second law of thermodynamics?

By focusing not just on the individual islands and continents of modern scholarship, but also on the many links between them, big history can provide a new framework for interdisciplinary thinking and research. Researchers familiar with big history's world map of the past will naturally seek out useful ideas and methods from beyond their own specialist disciplines. Transdisciplinary

35 Peter M. Hoffmann, *Life's Ratchet: How Molecular Machines Extract Order from Chaos* (New York: Basic Books, 2012), is a wonderful exploration of how molecular machines exploit the "molecular storm" created by the random energy of individual molecules to power the chemistry of cells; and why doing so does not breach the second law of thermodynamics, because it depends on additional sources of free energy, mostly supplied by the battery molecule, ATP.

research will become particularly important as more and more problems, from climate change to the study of cancer or financial crises, begin to depend on findings and insights from multiple disciplines. Indeed, the very success of research *within* disciplines explains why more and more interesting and important problems now lie *between* disciplines. As interdisciplinary research becomes increasingly important, big history can offer a new model of scholarly expertise, that demands breadth of knowledge and an alertness to unexpected interdisciplinary synergies.

The young discipline of big history has also shown that intellectual collaboration is a distinctive feature of our species, *Homo sapiens.* Though many evolutionary features define us as a species, our technological creativity seems to have been clinched by the evolution of an exceptionally powerful form of language that allows us to exchange ideas and insights with such precision and in such volume that they can accumulate in the collective memory. We know of no other species in which learned knowledge accumulates across multiple generations so that later generations know, not just different things, but *more* things than earlier generations. And this difference has proved transformative. The accumulation of learned information by millions of individuals across multiple generations explains our increasing control over the resources and energy flows of the biosphere. This accelerating trend has shaped much of human history, and has culminated today in making us the single most powerful force for change in the biosphere. In my own work, I have described our unique capacity for sharing and accumulating information as "collective learning." It has given us humans not only increasing control over flows of energy and resources through the environment, but also increasing insight into the world and the universe we inhabit. Modern science, as well as modern religions and literatures, are all the creations of millions of individuals, working within shared networks of knowledge. In just one century, the sphere of human mind, or the "Noösphere," as Vernadsky called it, has become a planet-changing force.[36]

My personal conviction is that the idea of "collective learning" offers a paradigm idea that can frame our understanding of human history and of the distinctive nature of our own species. Human history is driven by collective learning just as the history of living organisms is driven by natural selection. If this idea is broadly correct, it illustrates the capacity of big history to clarify deep problems by helping us see them against an exceptionally broad background, as part of the "world map" of modern knowledge.

Big history is a story. So far, I have discussed the nature of the truth-claims that can be made by big history, and its capacity to synergize collaborative, interdisciplinary research. But of course, big history also tells a story. It arises, as Carr wrote of all history, from "an unending dialogue between the present and the past." Its two poles are the past as a whole and the historians who view that past from a particular vantage point in the present. Like history in general, big history is very much a product of the historians who are constructing the big history story. That means, of course, that big history is evolving and will evolve, like all stories, as it is told by different tellers, writing in different contexts and with different preoccupations.

Big history is an origin story. But because of its universalist ambitions, big history is not just another story about the past. Its universal ambitions mean that big history shares much with traditional origin stories. As far as we know, all human communities have tried to construct unified accounts of the origins of everything that surrounds us. This is the sense in which I will use

36 On the idea of a Noösphere, see David Christian, "The Noösphere," from the Edge.org Annual Question for 2017 (Jan 2017), at https://www.edge.org/response-detail/27068

the idea of "origin stories." Origin stories attempt to hold together and pass on all that is known in a given community about how our world came to be as it is. They are extraordinarily powerful if they are believed, if they ring true to those who hear and re-tell them, whether we are talking about foraging communities of the Paleolithic world, or the great philosophical and religious traditions of major world civilizations, from Confucianism to Buddhism to the traditions of the Aztec world, of Christianity and of Islam. They are also powerful because they are shared by most members of a given community, who learn the rudiments of their origin stories as children, and then internalize those stories in the course of many years of education, with increasing detail and sophistication. As far as we know, origin stories can be found at the core of all forms of education. They have provided foundational knowledge in seminaries and universities, as well as in the rich oral traditions passed on by elders in all foraging communities.

In the light of this discussion it is apparent that Durkheim's notion of "anomie" can also be understood as the state of mind of those who lack access to a credible, rich and authoritative origin story. Intellectual anomie is a state of map-lessness and meaninglessness. Curiously, it is the intellectual state that became the norm in the twentieth century, as globalization and modern science battered confidence in traditional origin stories, both in the metropolitan centers of the world and at its colonial margins. Everywhere, modern secular educational systems ceased to teach within shared traditions of foundational knowledge.

Some found the decline of traditional origin stories exhilarating and liberating, and glorified in the multiple, free-floating perspectives of a world without a shared origin story. But many, both in the colonial world and in the metropolitan heartlands, experienced, and continue to experience, a deep sense of loss. Today, we are so used to a world without universal framing ideas (particularly in the humanities), that it is easy to forget how painful it was to lose the sense of intellectual coherence that goes with trust in an origin story. But that sense of loss is apparent in much of the literature, philosophy and art of the late 19th and early 20th centuries. Here are just two, more or less random, examples of what I mean. In his 1851 poem, "Dover Beach," Matthew Arnold writes:

> The Sea of Faith
> Was once, too, at the full, and round
> earth's shore
> Lay like the folds of a bright girdle furled.
> But now I only hear
> Its melancholy, long, withdrawing roar,
> Retreating, to the breath
> Of the night-wind, down the vast edges
> drear
> And naked shingles of the world.

The poem continues with a terrifying vision of a future without coherence or meaning:

> Ah, love, let us be true
> To one another! for the world, which
> seems
> To lie before us like a land of dreams,
> So various, so beautiful, so new,
> Hath really neither joy, nor love, nor
> light,
> Nor certitude, nor peace, nor help for
> pain;
> And we are here as on a darkling plain
> Swept with confused alarms of struggle
> and flight,
> Where ignorant armies clash by night.

W.B. Yeats' "The Second Coming," was written in 1919, just after the Great War seemed to realize Arnold's haunting vision of the future.

> Turning and turning in the widening
> gyre
> The falcon cannot hear the falconer;
> Things fall apart; the centre cannot hold;
> Mere anarchy is loosed upon the world,
> The blood-dimmed tide is loosed, and
> everywhere
> The ceremony of innocence is drowned;

The poem ends with a famous and terrifying image:

> what rough beast, its hour come round at
> last,
> Slouches towards Bethlehem to be born?

Specialization and the loss of traditional unifying narratives were symptomatic of the chaotic and incoherent world described in so much twentieth century literature, art and philosophy. Indeed, it has often been assumed that this world of isolated, even incommensurable disciplines and perspectives is characteristic of modernity in general. The modern world threw together peoples, cultures, religions and traditions so violently that it created a growing sense of a single humanity, while undermining confidence in traditional visions of the world. In the *Communist Manifesto,* we read that, in the bourgeois era of human history: "All fixed, fast-frozen relations, with their train of ancient and venerable prejudices and opinions, are swept away, all new-formed ones become antiquated before they can ossify. All that is solid melts into air, all that is holy is profaned, …" In a book on modernity that takes its title from this passage, Marshall Berman writes that the modern world has created: "a paradoxical unity, a unity of disunity; it pours us all into a maelstrom of perpetual disintegration and renewal, of struggle and contradiction, of ambiguity and anguish. To be modern is to be part of a universe in which, as Marx said: 'all that is solid melts into air.'"[37]

But a different interpretation is also possible. Perhaps for much of the twentieth century, we have lived in a sort of intellectual building site, surrounded by the debris of older origin stories, while a new origin story was being constructed all around us, a story for humanity as a whole. The best evidence for this idea is the re-emergence of new unifying stories in the last fifty years. Seen from this perspective, big history is the project of trying to tease out and build a modern, global origin story.

Big history is an origin story for the Anthropocene Epoch. Perhaps, then, we can think of big history as an origin story for the twenty-first century. Big history builds on the intellectual achievements of modern science, but it is also the product of an increasingly globalized world, that is very different from the world of E.H. Carr. Scientific knowledge has advanced faster than he could have imagined, and new technologies such as the Internet have created a much more intertwined world. But perhaps the most important changes arise from the great acceleration, the astonishing increase in human numbers, human energy use, human control over the environment, and human inter-connectedness, in the sixty years since Carr wrote. In that brief period, we humans have collectively become the single most important force for change in the biosphere, the first single species to play such a role in the 4 billion year history of life on earth. That is an outcome that Carr could not have imagined in 1961. These spectacular changes mean that questions about the nature and source of the astonishing power wielded collectively by 7.4 billion humans loom much larger today than they did in Carr's time. In this sense, big history can be thought of as an origin story for the Anthropocene Epoch of human history.

37 Marshall Berman, *All That is Solid Melts into Air: the Experience of Modernity (*New York: Penguin, 1988, 1st published 1982), 15.

We will need the broad scale of big history to see the Anthropocene clearly, because it is not just a turning point in modern world history, but a significant threshold within human history as a whole, and even in the history of planet earth. Most contemporary historical scholarship studies the last 500 years. The danger of this foreshortened perspective is that it can normalize recent history, making the technologically and economically dynamic societies of recent centuries seem typical of human history in general. They are not. Their dynamism is extraordinary and exceptional. The very idea of history, of long-term change, is modern and, as John McNeill has shown, the scale of change in the modern era, and particularly since the mid twentieth century, really is "something new under the sun."[38] In contrast, most people in most human societies over the last 200,000 years lived lives whose structures and surroundings seemed relatively stable, because change was so slow that it could not be observed at the scale of a few generations.

Only within the capacious scales of big history is it possible to see clearly that the Anthropocene Epoch is strange not just on human scales, but also on those of the history of planet Earth. This is perhaps why, in a recent article, a group of paleontologists suggest that the Anthropocene Epoch counts as one of the three most important turning points in the history of the biosphere, along with the emergence of life, almost 4 billion years ago, and of multicellular life 600 million years ago.[39] Never before has a single species dominated change in the biosphere as we humans do today, and never before has the near future depended as it does today, on the decisions, insights, and whims, of a single species. Appreciating the strangeness of modern society is vital if we are to tackle the global challenges it poses for the near future. Understanding how strange today's world is may also give us a renewed appreciation for the insights and understanding of our ancestors, who maintained over many millennia a much more stable relationship with the biosphere as a whole.

Big history is the first origin story for all humans. If big history is an origin story, it is also the first origin story for humanity as a whole. Emerging as it does in a densely interconnected world, it is the first origin story constructed by, and available to, all human beings. While traditional origin stories tried to sum over knowledge from particular communities or regions or cultural traditions, this is the first origin story that tries to sum over accumulated knowledge from all parts of the world. That alone suggests the wealth of information and the astonishing richness of detail of a modern origin story.

Traditional origin stories provided a unifying vision for particular communities, by highlighting the ideas that different people shared, just as modern national histories provided a unifying vision for nation states despite internal differences of language, culture, religion and ethnicity. In a similar way, the big history story can start to provide a unifying vision for humanity as a whole, despite the many differences between regions, classes, nations and cultural traditions. The construction and dissemination of a global origin story can help generate the sense of human unity that will be needed as human societies navigate collectively through the global challenges of the next few decades. Though the national and cultural tribalisms that dominated Carr's world are still very much present today, he would have been astonished to see, emerging alongside them, an origin story for humanity as a whole.

38 For more on these claims, see David Christian, "History and Time," *Australian Journal of Politics and History* 57, no. 3 (2011): 353-365, and John McNeill, *Something New under the Sun: An Environmental History of the Twentieth-Century World* (New York: W. W. Norton, 2000).

39 Mark Williams, Jan Zalasiewicz, et. al., "The Anthropocene Biosphere", *The Anthropocene Review,* (2015): 1-24.

So interconnected is today's world that the idea of a unified humanity with a history of its own has a salience that it lacked in Carr's time, when the most significant human communities seemed

to be either nation states or culturally cohesive regions such as "the West" or the Muslim world, or the zones dominated by great traditional empires such as China or India. Today, a sense of global citizenship, of belonging to the global community of humanity, is not just a matter of scientific precision. (Generically speaking we are, after all, a remarkably homogenous species, so that the category, *Homo sapiens* has a scientific precision that the category of "Chinese human being" or "American human being" lacks.) Awareness of what all humans share is increasingly a matter of self-preservation, particularly in a world with nuclear weapons. E.H. Carr wrote "What is History?" one year before the Cuban missile crisis, when, according to President Kennedy, the odds of an all-out nuclear war lay "between one out of three and even."[40]

H.G. Wells' attempt to write a universal history in 1919, when the horrors of the Great War were still vivid in his mind, was driven by a similar sense of human unity. Peace, he argued, required new ways of thinking. It required:

> . . .common historical ideas. Without such ideas to hold them together in harmonious co-operation, with nothing but narrow, selfish, and conflicting nationalist traditions, races and peoples are bound to drift towards conflict and destruction. This truth, which was apparent to that great philosopher Kant a century or more ago . . . is now plain to the man in the street.[41]

More recently, the great American world historian, William McNeill, has made the point with equal eloquence:

> Humanity entire possess a commonality which historians may hope to understand just as firmly as they can comprehend what unites any lesser group. Instead of enhancing conflicts, as parochial historiography inevitably does, an intelligible world history might be expected to diminish the lethality of group encounters by cultivating a sense of individual identification with the triumphs and tribulations of humanity as a whole. This, indeed, strikes me as the moral duty of the historical profession in our time. We need to develop an ecumenical history, with plenty of room for human diversity in all its complexity.[42]

As Wells understood, a universal history is the natural vehicle for a unified history of humanity, because, unlike national histories, big history first encounters humans not as warring tribes, but as a single, and remarkably homogenous, species. And it is a story that can now be told with increasing precision and confidence, and can help us understand the place of our species not just in the recent past, but in the history of the biosphere, and of the entire universe.

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40 Graham Allison and Philip Zelikow *Essence of Decision: Explaining the Cuban Missile Crisis*, 2nd ed. (New York: Longman, 1999), 271.

41 H.G. Wells, *Outline of History,* vi.

42 William H. McNeill, "Mythistory, or Truth, Myth, History, and Historians," *The American Historical Review* 91, no. 1 (Feb. 1986), 7.

On the pursuit of academic research across all the disciplines

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Introduction

This article is about similarities and differences in the pursuit of academic research all across the disciplines. It forms part of my efforts in the field of big history to find a common language and understanding for all its practitioners, both big historians and specialists from all the academic fields that contribute knowledge to big history.

Over the course of time, all these different academic disciplines have come to employ their own specialized methods and languages, which sometimes overlap, while they do not at other times. Furthermore, some of the terms used, such as 'system,' 'energy,' and 'meaning,' may look the same, yet they have acquired different meanings in different academic arenas.

All of that does not matter too much as long as these disciplines stay apart while their practitioners understand each other well within their own fields. However, the effort of big history to bring all these disciplines together into one single coherent account has inevitably led to a need to confront these issues in an effort to shape one single common language. This discussion has barely begun, not least because the problem may not yet have been sufficiently recognized. As a result, currently many such misunderstandings seem to abound.

In this contribution I do not seek to confront all these issues. That can only be done in a long and intensive discussion involving a great many scholars. Here I will focus on only one aspect, academic research, while, of course, I do not expect to present any final views about this topic. Yet it is my hope that this article will stimulate a discussion with the aim to achieve a clearer understanding of what all academic researchers have in common.

A major source of misunderstandings may be the incorrect perceptions that appear to exist within the field of the natural sciences of how the humanities and social sciences pursue research, or ought to do so, and vice versa. I experienced that firsthand while first engaging in the natural sciences, and later also in the social sciences. Most notably this seems to be the perception that natural scientists are doing hard, serious science, while the rest is not, and that the rest could only turn into a serious science by using the methods of the natural sciences (which are often misunderstood within the field of the humanities).

In practice I have found, however, that although the research subjects and, as a result, the methods used to pursue investigations, are different, the underlying approach of how to engage in academic research is, in principle, exactly the same. Clearly, the academic study of far more complex subjects, such as life and human societies, entails specific problems that natural scientists never have to face. This has deeply influenced the development of the humanities, including the social sciences. But even though the research subjects and the methods employed may be very different, the underlying general approach of how to do research seems to be identical. This will be discussed below in more detail.

This article is an elaboration of an essay dating back to the 1980s. The first draft was written in 1984 while I was studying cultural anthropology at the Free University Amsterdam (Spier 1984). It dealt with empirical academic research all across the sciences; on the interests served by doing empirical research; and on ethical questions that might arise as a result. At that time I was preparing my cultural anthropological and historical field research on religion and politics in Peru, which would hopefully involve living in an

1 I am indebted to an anonymous reviewer for excellent suggestions on how to improve this article.

Andean village while studying its present and past. I felt it was important to reflect on these things beforehand, because I wanted to understand as well as possible what I was setting out to do.

Before studying cultural anthropology, I had received a M.Sc. in biochemistry 1978 at Leiden University. While introducing me to the natural sciences ranging from physics and quantum mechanics all the way to microbiology, this study had included a considerable amount of research into various fields, most notably synthesizing and isolating a number of chemical compounds. As a result, the intensive years between 1970 and 1977 that I spent in the Leiden laboratories had allowed me to gain a first-hand experience of how the empirical scientific method worked in practice, not least thanks to the many open and sometimes revealing discussions that I had been part of within the safe confines of those laboratories. My knowledge was further shaped by taking part in a discussion group that explored the most recent ideas about the history and philosophy of science.

While studying cultural anthropology at the Free University Amsterdam in the 1980s, I took a few philosophy courses, which further improved my views. All of that, including my growing knowledge of how the social sciences worked in practice, provided the intellectual background for my essay of 1984. I then felt that even though the objects of investigation and, as a result, also the methods of investigation, were very different, the general approach across the sciences seemed to be identical.

After having returned from Peru in 1986, I confronted my 1984 ideas with my experience of pursuing cultural-anthropological and historical studies in a Peruvian Andean village (Spier 1986). To my delight, I did not have to change a single idea. But I did find that the essay could be enriched with my experiences. So I wrote an improved version, which became one of the required assignments for obtaining my M.A. in cultural anthropology (Spier 1987). Even though now almost thirty years have passed since writing that essay, I still stand by the general view that was penned down at that time.

The 1984 reflections were written on a typewriter, because the computer desktop revolution had not yet reached our university in the Netherlands. After my return from Peru in 1986, however, during which I had shared life with Andean farmers who lived in circumstances that were in many ways similar to those of peasants in the European Middle Ages, while in the cold sacristy of the village church I had transcribed ancient documents that had partially been consumed by rodents, the computer revolution had taken place.

One of the first things that needed to be done was, therefore, mastering this brand new technology: learning to use desktop computers with two large floppy disk drives, one drive for the MS-DOS program and the text-processing program WordPerfect, and the other drive for saving the files. Of course there was no Internet yet. On this exciting but challenging technology my Andean data were recorded and elaborated using the WordPerfect program, with the aid of which also my improved essay on the scientific method was written. This made it possible today, using a much more recent version of WordPerfect –still my preferred word processor application–, to effortlessly use those (now) ancient computer files.

The essays were written in Dutch. As a result of discussions with big historians, especially regarding the seeming lack of understanding among natural scientists and academics from the humanities about what they share while engaging in doing academic research, I began to wonder whether it would be helpful to translate those ideas into English. This article is the result of that effort. A few insights have been added that seemed so obvious to me at the time that they did not need to be mentioned. Yet they may not always be obvious to practitioners of the humanities or to readers who are not academically trained. A few other insights were added to illustrate or further elaborate certain aspects.

The essay below is, therefore, a reworked version of the first section of my 1987 essay, which reflected on the empirical academic research. The second section, which was a reflection on the interests served by doing empirical research as well as on ethical questions that might arise as a result, is not included here.

What does the pursuit of academic research consist of?

Before discussing the pursuit of academic research in more detail, it seems important to make a fundamental distinction between two different ways in which humans face the world. The first way can be called 'direct experience.' Everybody experiences the world in a direct way and reacts to it. Such experiences, as well as the resulting feelings can be expressed, among other things, in daily conversation and with the aid of gestures of many kinds, but also in literature, music, dance, decorations, etc. Direct experience and the resulting reactions are the ways in which most humans live their lives most of the time. The US philosopher Robert Pirsig (1928-) called this the 'romantic mode of understanding' (1976, p.66 ff.), while in his book *Involvement and Detachment* (1987) the German sociologist Norbert Elias (1897-1990) used the word 'involvement' to characterize this attitude.

A second way of dealing the world is thinking in terms of underlying forms. While doing so, one takes distance from one's direct daily experiences and starts looking for underlying patterns that may describe and explain the observed events and regularities. In this approach, the leading questions are: "how do certain things work, and how and why are these things happening the way they do?" Norbert Elias called this attitude 'detachment,' while Robert Pirsig uses the term 'classic mode of understanding' (1976, p.67 ff.). In short: these are forms of rational thinking. These underlying forms include a wide range: daily reasoning, all kinds of formalized regimes of thought such as writing and musical notation; religious, normative, ethical and philosophical ways of understanding the world, all the way down to the ways academics pursue research.

This essay addresses the question: what distinguishes empirical academic research from all the rest of human experience and thought, and how is it connected to it?[2] Before focusing on this question I would like to emphasize that in my personal opinion, both direct experience and thinking in terms of underlying forms are essential in our human existence, while I see them as equally valuable.

However different these two ways of approaching the world may be, in practice they are always connected. Surely, there is often, if not always, some interplay between direct experience and thinking in terms of underlying forms, including research performed by academics. When I am trying to play the guitar, for instance, I need some knowledge of underlying form about how the notes and chords are structured on this musical instrument. Yet that is not enough. Playing music first of all involves trying to express and convey certain feelings, in other words: direct experience. Without it, playing the guitar would yield only a technically-executed sequence of notes without any emotional value. We will find a similar interplay when academics are pursuing research, but with a different emphasis on what

2 An anonymous reviewer pointed out that "Daniel Kahneman's distinction between 'fast' and 'slow' thinking may be similar, if not the same, including how natural selection may have generated methods for rapid reactions and also for slower, more careful thinking (rationality?)" (Kahneman 2011).

the end result should look like. The first question that needs to be pursued is, therefore: what distinguishes academic research from all other forms of thinking in terms of underlying forms, and how did it emerge?

How did academic research emergence in Europe?

Over the course of many centuries, constellations of people have emerged in Western Europe and elsewhere who have given special emphasis to a rather strict approach of thinking in terms of underlying forms in relation to empirical observations, while practicing and developing it in specific ways. This approach was first institutionalized in specific houses of learning, in Europe most notably universities and royal academies. Over the course of time, also other institutions emerged where empirical science (in an increasingly broad sense) is practiced, such as today in a great many research institutions.

To be sure, the European universities were preceded by similar scholars and institutions in many parts of the world. Yet the European model, especially the 'Humboldtian' model of open-minded research and teaching first institutionalized by Wilhem von Humboldt (1757-1835) and his colleagues at Berlin University in the early nineteenth century, has become very influential, while it has been copied all around the world. Because of its relentless emphasis on rational thinking, Robert Pirsig called the university system the 'Church of Reason' (1976, p.140). This specific approach of thinking in terms of underlying forms about empirically observed reality is the essence of the academic pursuit of understanding reality.

Before continuing this discussion, it may be useful to reflect a little on the meanings of the word 'science.' In Latin, 'sciencia is derived from the verb 'scio,' which means both 'to know' and 'to understand.' These words do not point to any types of feelings. In the formal academic approach it is all about thinking in terms of underlying forms: regularities and generalizations of direct empirical observations. In the Anglo-Saxon world the term 'science' has come to mean the 'natural sciences,' while the social sciences and the humanities are seen as rather different academic pursuits. Yet in language areas such as German and Dutch such a distinction is not made. To avoid any confusion about this here, the term 'science' is therefore used very sparingly, while the preferred term is 'academic research.' This is all part of the attempt of seeking to find an unambiguous common vocabulary that may be helpful to improve communication across all the academic disciplines.

As mentioned before, most forms of thinking in terms of underlying forms are not regarded as science. In all societies, for instance, there are more or less formalized prescriptive rules concerning how to behave. In most, if not all states such rules have been written down in the form of law, which today also includes huge amounts of jurisprudence. These regimes of thinking in terms of underlying forms are not meant to explain why people behave the way they do. They simply define and prescribe the dominant rules of behavior, including what should happen if people do not follow these rules. This is only one example from the large field of regimes of underlying thought that are not part of the process of empirical academic research. Such regimes can, of course, become a subject of academic research.

What are the fundamental requirements of academic research?

So what can be regarded as empirical academic research? To deserve that qualification, a regime of thinking in terms of underlying forms must fulfil at least four strict requirements.

<u>The first requirement is logical consistency</u>. The formulated regularities should follow the

strict rules of logic, most notably that they never contradict each other. Most, if not all, academics are constantly testing both their own thought structures and those of others on internal and external logical consistency. In other words: a hypothesis or theory must follow these rules and not contradict itself, while it must not contradict other established theories either, unless the purpose is to undermine such a theory.

To my knowledge, the oldest extant standardized forms of logic in Europe were formulated by Aristotle (384-322 BCE). These rules appear to have universal application. While most academics may lack formal logical training, most, if not all, of them appear to be able to apply these rules more or less intuitively with great success. It may well be that this form of thinking is genetically ingrained to some extent in our bodies as part of the long evolutionary history of our species, and perhaps in many earlier life forms as well, as a result of their attempts to map the world and act sufficiently successfully while using those maps to survive the onslaught of the process of biological evolution first outlined by Charles Darwin (1809-1882) and Alfred Russel Wallace (1823-1913).

It is important to see that this requirement of consistency, including no contradictions, is an assumption imposed on the academic method. Although deemed unlikely, it cannot completely be ruled out that nature may be contradictory from time to time. So we may want to keep our eyes open for such possible events. If we find them, it would fundamentally alter the academic method.

<u>The second requirement is that a theory or hypothesis must be able to explain, or at least provide some structure to, empirical observations</u>. This means that empirically-observed situations can be seen as part of more general structures. This is the ultimate goal of empirical academic research.

Because empirical observations are part of the domain of direct experience, this is what links that domain with the domain of thinking in terms of underlying form. But not all observations can be called empirical observations. Claims, for instance, to have witnessed certain events such as the appearance of gods may be called personal observations. But such observations cannot be called academic empirical observations as long as they cannot, in principle, be observed by other trained academics (or could have been witnessed by them, if they had been present when that happened). In other words, empirical observations must be social events within the world of academia. To be sure, the interpretations of empirical observations and even their descriptions may – and often do – differ.

For instance, the claim to have seen a stationary very bright star in a very particular place in the sky about 2000 years ago during an event deemed unusually important is not, by itself, an empirical observation, unless it is confirmed by other observers. In consequence, astronomers may search old records for such possible events that were observed and recorded by others. Alternatively, researchers may seek to reconstruct unusual events in the sky during that particular period of time based on empirical data as well as on their knowledge of celestial processes, such as rare conjunctions of planets and stars, or perhaps exploding stars called supernovae.

If academics find such events, this may turn the other observation into a possible empirical observation, even though the interpretations may be very different. However, the claim that a bright star stood still in the sky for a longer period in time is likely to be contested by academics, because no empirically observed stars have ever done that, with the exception of Polaris, the pole star, which is currently situated virtually right above the North Pole and, as a result, appears (almost) stationary in the sky as seen by earthbound observers. Yet around 2000 years ago that was not the case, while there was, to our knowledge, no other star at that time that occupied Polaris's current position above the North Pole.

This raises the question of how to decide when one particular theory should be considered 'better' than another one. The great majority of academics think that the criterion is simplicity: the preferred theory contains the fewest general rules while structuring and explaining the largest number of empirical observations. This principle, called parsimony, is also known as 'Occam's razor,' named after the English cleric, William of Ockham (c.1287–1347), who formulated this principle very clearly.

Furthermore, this raises the question of what 'explaining' means. It turned out not to be very easy to answer that question unequivocally. A great many scholars have sought to clarify this, including Scottish philosopher David Hume (1711-1776), followed by Prussian philosopher Immanuel Kant (1724-1804), the "Wiener Kreis" (Vienna Circle) philosophers, Austrian-British philosopher Karl Popper (1902-1994), and US scientist and philosopher Thomas Kuhn (1922-1996). I do not want to pursue this question here in any detail. But clearly, for achieving a good understanding of academic research it is very important to carefully explore what the nature, possibilities, and limitations of explanations are.

This also raises the question of how much empirical certainty theories would provide. Sir Karl Popper pointed out that because we will never be able to know all empirical data, we will never be able to formulate with absolute certainty any general rules that will cover all empirical data. In consequence, structuring and explaining empirical data will always remain uncertain to some extent.

This implies that the results of science are always uncertain to some extent, although in many cases the uncertainty may be limited. For instance, the great improvement over the past decades of scientific insights and their practical applications concerning the construction and operation of airplanes has led to a remarkable decrease in the number of serious accidents per passenger and per distance covered, which are now far lower than they have ever been. Apparently, these insights are ever more reality-congruent, in Elias's terms, in the sense that they contribute to building and operating airplanes that do not randomly fall out of the sky. And as soon as a serious accident happens, huge efforts are made using academic research to find out what went wrong in order to prevent this from happening again. That is how academic research works, and this has led to this remarkable success. A great many similar examples could be given, all indicating the enormous advances in uncertainty reduction that has taken place within those fields. However, not all academic pursuits have led to similar successes. More about that below.

<u>The third major requirement is that empirical data that are seen as sufficiently solid should not contradict our hypotheses or theories</u>. In this context, Karl Popper used the word 'falsification,' with which he meant that when one single empirical observation considered sufficiently solid is found to be in contradiction with a theory, this should lead to the rejection of that particular thought structure.

This means that all hypotheses and theories are in principle 'open-thought regimes,' because all theories can in principle be tested with the aid of empirical observations. These open-thought regimes are in stark contrast with 'closed-thought regimes,' within which any event can be explained without ever casting any doubt on the underlying thought structures. Examples of closed-thought regimes can, most notably, but certainly not exclusively, be found in religions.

In other words: an academic theory must in principle be open to rejection if it does not conform to established empirical observations. In practice, however, as Kuhn observed in his ground-breaking book *The Structure of Scientific Revolutions* (1970), theories tend to exist in the midst of unexplained observations that are temporarily cast aside. By slightly changing or refining theories, many recalcitrant observations may be accommodated, at least for a certain period of time. For instance, the epicycles used by Ptolemy to explain the planetary movements in his model of the solar system with Earth at its center offer a famous example of such a refinement. In fact, such attempts at refining theories happen most of the time when discrepancies between theory and empirical observations arise. Most academics are understandably wary of quickly abandoning a theory that has worked well in the past. Such a tendency may well have emerged as a result of biological and social evolutionary pressures that our species has experienced during its history.

Yet, as Thomas Kuhn further explained, some observations turn out to be so difficult to reject or accommodate within a theory that they may lead to a state of chaos within the discipline. To overcome this unpleasant situation, new theories are advanced for explaining these observations in different, often more all-encompassing ways. Over the course of time, this will lead to the replacement of the old theories by the new ones. The discovery of the photo-electric effect and Albert Einstein's explanation of it, which earned him a Nobel prize in 1921, leading to the emergence of quantum mechanics (which Einstein did not like), offers a clear example of such a change. Also the emergence of big bang cosmology and plate tectonics can be understood in such ways. Interestingly, these novel academic insights were gaining ground while Kuhn was writing his book, yet he did not mention them then in his writings. One may wonder whether these academic developments may have stimulated Kuhn to undertake his research, even though he may not have been sufficiently aware of them at that time. Furthermore, as Kuhn explained, empirical observations never yield absolute facts. All observations are always interpreted before becoming academic observations. This inevitably introduces elements of uncertainty. As a result, the description and interpretation of empirical observations may change over time. A practical example from physics may clarify this:

> It is possible to determine the concentration of compounds in a solution by measuring the amount of light that is absorbed by that compound. The more light 'disappears,' the more 'stuff 'is present in that particular solution. But the scientist who does such an experiment should never assume that by just reading the meter (empirical observation) the concentration of that compound is known with absolute certainty, because possibly: 1. The meter is not calibrated correctly; 2 the glass vial or the lens is dirty; 3. there are other compounds in the solution that also absorb light; 4. The relationship between absorbed light and concentration is different from expected, and so on.

This list of uncertainties concerning the interpretation of empirical observations is endless. If one reflects long enough on these things, new aspects may be found that may influence one's observations or one's interpretations of them.

This is the case for all empirical observations. No single fact can be established beyond any doubt, simply because all empirical observations entail forms of interpretation (cf. also Kant 1976). Just think of what a piece of rock might look like to a lay person without any knowledge of chemistry or geology; what it would have looked like to a geologist a century ago; and what it would look like to today's geologists trained to observe them with the latest chemical and geological concepts and methods. And, following Kuhn's argument, this situation becomes even more serious when empirical observations are described and interpreted with the aid of competing theories. As a result, academics from different fields may not be able to communicate effectively with each other any more. In consequence, as Kuhn argued, the transition from an older to a newer theory may also involve a redefinition of empirical observations.

This uncertainty has worried academics, because they feel that their fields ought to be built on more secure foundations. In trying to tackle that issue, before the Second World War scientists united in the 'Wiener Kreis' sought to establish a theory of science based on pure experience. Their huge efforts and spectacular failure have emphasized that pure empirical observations without any form of theoretical interpretation do not exist. In other words, theories and empirical observations are always linked to some extent, which greatly complicates the testing of competing theories.

In other words: within empirical science it is impossible to make an absolute distinction between 'objects' and 'subjects,' simply because the results of academic research always consist of images of the world produced by humans. They may represent the best available academic descriptions today. But they never represent the only possible interpretation of the world itself, and should never be seen as such. In consequence, these images always inform us something about both the observer and the observed, even though often great efforts are made to push the balance in such a way that the information is mostly about the observed world and as little as possible about the observers.

Yet both influences are always present in academic reports. As a result, such accounts can always be read as informing us both about the result of academic research and about the backgrounds of the particular researchers. In fact, I stimulate my students to engage in both types of reading. Even though the results of academic research may not require accounts of the researchers' personal experiences, any understanding of the process of academic research does require such knowledge. That is why I myself am always very interested in such personal stories.

How does such often hard-gained knowledge become academic knowledge? To be recognized as such, this knowledge needs to be shared and discussed among colleagues. In other words, <u>the fourth fundamental requirement of academic knowledge is that it is socially shared</u>. Inventing theories and making empirical observations may well be a private affair. But they turn into academic knowledge only after having become discussed and accepted among academics, at least to some extent. A famous anecdote may illustrate this:

> In the 17th century, a competition among scientists was going on in London concerning the question of who could explain why Earth's orbit around the sun was an ellipse. One day in 1684, the famous physicist Edmond Halley (1656-1742) visited Isaac Newton (1642-1726), who was then living a rather secluded life in Cambridge. Halley posed Newton the question: "what is the shape of Earth's orbit around the sun?" based on Robert Hooke's suggestion that the attraction between the sun and the Earth followed the law of inverse square of the distance. "An ellipse," replied Newton. "How do you know that?" was the next question. "I calculated it," replied Newton. He claimed to have solved that problem 18 years earlier,

> but was unable to find his notes. Halley persuaded him to elaborate this idea mathematically, which led to one of the most famous books ever written in science *Philosophiae Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy)* published in 1687. At that moment, Newton's private efforts became more generally known, and thus turned into academic knowledge.

After having formulated these four fundamental requirements, it has become possible to offer a definition of empirical academic research, as follows:

> "Empirical academic research consists of a very specific form of thought in terms of underlying forms aimed at formulating general principles that can structure and explain empirical observations. These underlying principles must be logically consistent, while they must be obtained in a continuous process of confrontation with both the available empirical evidence and the established theories. The results of these efforts must be shared with other academics."

Non-rational influences in academic research?
Before exploring the definition of academic research just mentioned, it seems important to pay some attention to the fact that also non-rational aspects are extremely important while engaging in such investigations.

First of all, every empirical researcher investigates something. But what? Why was that particular research topic selected, and not another one, or nothing at all? Such choices can never be determined in totally rational ways. The investigation is done because of the importance attached to it. It is a choice determined by the researcher and/or by the persons facilitating the research. As a result, making such choices goes way beyond the formal approach of academic research and its results, even though a good knowledge of academic research may well have contributed to arriving at such decisions.

In other words, these choices depend on the feelings, value judgments, their knowledge, and the social possibilities and limitations of all the people involved in such activities. All of this belongs to the domain of direct experience as well as perhaps to other fields of thinking in terms of underlying forms. As a result, these choices can never entirely be legitimized only by referring to the principles of formal academic research. While academic research is a tool for achieving specific goals in specific ways, it is not driving the process of investigation.

As soon as the choice for a certain object of investigation has been made, this determines to some extent the academic insights and methods that are going to be used. It is not a good idea, for instance, to do chemical experiments entirely based on cultural anthropological insights. And it is equally unproductive to investigate social behavior by exclusively using theories of the chemical bond. It would not make a great deal of sense to take Peruvian farmers apart and separate their molecules in an ultracentrifuge if one wanted to know their social situation, or seek to isolate DNA molecules by observing certain organisms.

Yet comparisons of theories and methods from different fields may lead to new and interesting insights. In his book *What is Sociology?*, for instance, Norbert Elias fruitfully compared molecular bonds with human bonds while advancing his theory of 'human figurations' (1978a, p.72). He could do so thanks to the fact that he had studied medicine before becoming a sociologist.

Also, while engaging in academic empirical research, non-rational aspects abound. Why, for instance, would a researcher follow certain research strategies and not others? Why would that person observe certain particular aspects and not others? How would all of that be done in ways that work well? And why would certain hypotheses be formulated and not others, out of the thousands of possible hypotheses? And where would all these ideas come from?

The answer 'logical thinking' is not fully satisfactory. Everyone who has seriously engaged in empirical academic research knows that such insights tend to appear quite suddenly, much like the proverbial light that goes on. At such moments, the researcher intuitively feels that this is the direction that should be taken, or what the solution for that particular problem might look like. The next step is to check very carefully and argue whether these ideas are indeed academically correct. This is done by painstakingly confronting them with all the available empirical evidence and existing theories using rational thinking, and quite often, also by making new observations that may, or may not, confirm those ideas.

This long and often painful process of careful rational, logical reconstruction takes place after the new idea has emerged as a result of intuition. It is absolutely essential to turn such ideas into science. During the process, most ideas are rejected, while the ones that survive may guide the researcher into further pursuing her or his investigations, including further observations and experiments. But the ideas for doing such things come first of all as a result of intuition. In other words: academic research consists of a great many rigorous logical reconstructions of a path that is found by following one's intuition.

Surely, having such intuition is only possible when the researcher has become well versed in her or his field, often after having spent a great deal of time mulling over these problems. That is a most important precondition. But even though knowledge of the field is essential, it may also be helpful to enter the field as a complete outsider. In such a situation, the investigator's thoughts and reflexes have not yet been shaped to the extent that many questions are considered too obvious to ask, while new solutions may be hard to see. This is a major reason why, I think, that, for instance, in physics young researchers are usually the ones who produce the most refreshing insights. As Norbert Elias explained in his memoirs, growing up as Jew in Germany helped him to analyze societies more at a distance. The world historian, William H. McNeill, once wrote me that starting out as Canadian citizen but living in the United States helped him to see things that many of his American colleagues seemed to miss. And in my Peru research it was very helpful, in retrospect, that I knew very little about that country before starting my investigation. It allowed me to look at what I witnessed with a fresh, often confused, look, taking far less for granted as a result, while asking a great many dumb questions that no one else would have posed who was more familiar with those situations. Of course, I worked very hard to improve my knowledge, which went hand-in-hand with almost continuous observations and discussions with everybody who was willing to enter into a conversation with me. All of that was driven by intuition and personal motivation. The following personal experience shows such a process in action.

> At a certain point in time I began to wonder what the social process had been that had led to the construction of the great many ancient Inca agricultural terraces on steep mountain slopes in places such as Pisac and Machu Picchu that seem to defy gravity. I had visited those places myself, and wondered why these terraces had been built in such seemingly impossible places, and why not in places that were lower down the valley where they were easier to construct and quite likely to be more

> productive (which was the case near the Andean village of Zurite were I lived). No one seemed to have posed those questions, to my knowledge. I was not aware of any references to such questions in any of the Spanish chronicles either.
>
> In Zurite I had often witnessed the way in which many public projects were executed, namely with the aid of competing workgroups within a regime called *faina*. I had also noticed that competition among these groups for the prestige of having done the best job very much contributed to driving the process to its successful completion. Not least because all armies known to me appeared to have fought more effectively when subdivided into competing groups, I began to wonder whether the Incas would have employed a similar process of competition to construct these 'high prestige' terraces. In those places, all very strategically located, military garrisons would have been stationed. Also in an effort to prevent idleness from kicking in and leading to all kinds of mischief, these Inca soldiers might have been obliged to compete in constructing those terraces and grow food on them after their completion, so that they could provide their own sustenance. When I floated this hypothesis to farmers from Zurite during informal conversations, their faces lighted up. They immediate agreed that this could have been how it had been done. This does not provide any proof, of course, that it was done in such a way, but it does add some plausibility to this hypothesis (cf. Spier 1994, p.64, note 3).

One may wonder how the seemingly magical appearance of such ideas works. Apparently, as part of our biological and social evolution humans have become equipped with a solution-finding mechanism in our brains and bodies that helps us to come up with, and select for, 'sufficiently good' solutions out of the great many possibilities that may exist, while combining knowledge from different domains. I am not familiar with any studies that elucidate how this mechanism might work, or how it may have emerged. But that probably only reflects my own ignorance of these fields. But surely this mechanism exists, and there must be a neurological and molecular basis for it.

In sum: although a sound knowledge of the academic method is indispensable for achieving success in empirical research, the practice of doing it is determined by choices that are not entirely based on the formal method. Taking one's intuition seriously offers a major link between the world of direct experience and that of thinking in terms of underlying form. How to do this well is the central theme of Pirsig's brilliant book.

To what extent can similarities in academic research be found all across academia?

By defining academic research in the way explained earlier, nothing has yet been said about its contents, and nothing either about the choices for a certain type of investigation. All theories can be called 'academic' as long as they conform to the general requirements mentioned. In other words, the definition seems valid for all branches of empirical academic research, from the natural sciences all the way to the humanities.

Both in the field of the natural sciences and in the field of the humanities and social sciences it is often thought that the natural sciences constitute 'harder,' 'more rigorous' forms of empirical academic research. From the point of view advocated here, in terms of the general nature of academic research this is a misunderstanding. Yet in terms of content this may often be a correct assessment, depending on what one would call 'hard' and 'rigorous,' of course, such as the existence of generally-accepted theories and reproducible data. This situation is at least partially the result of the fact that natural scientists have a much easier job than their colleagues in the humanities, because they investigate far less complex aspects of reality, while scholars of human culture deal with the most complex aspects of reality known to us.

Yet that situation should not necessarily cause the humanities, including the social sciences, to be less rigorous in terms of empirical academic research. Thomas Kuhn argued –and I fully agree with him– that this difference is mainly caused by the fact that within the social sciences it has not yet been possible to establish generally-accepted theories, or paradigms, as Kuhn called them. While the main cause for this situation may be that the humanities deal with aspects of reality that are so much more complex than those examined by natural scientists, which makes it much more difficult to establish general paradigms, this is not necessarily the end situation. This will be elaborated below.

Yet it is, in my view, a misunderstanding to think that the natural sciences are essentially different from the humanities which would make the establishment of general theories in the humanities impossible. Surely, the objects of investigation are of another nature, and this requires different research methods. As mentioned earlier, it is not a good idea to research atoms and molecules the same way as living nature or human societies. Furthermore, because atoms and molecules, stars and planets, rocks and oceans, do not show emotions and do not communicate with each other or with the researcher, while they do not have intentions or assign meanings to the rest of nature, it is much easier to investigate them academically from a greater distance. And the huge numbers of atoms and molecules involved, which are often very similar, allow researchers in the natural sciences to use statistical methods with greater success.

More in general, the lower levels of complexity involved in the natural sciences have allowed their scientists to formulate more precise natural theoretical principles with greater success than elsewhere within academia, and use them successfully to predict the outcomes of controlled experiments or the nature of relatively simple aspects of reality. All of that has led to an ever-increasing human control over the rest of nature. Yet, as Norbert Elias argued in *Involvement and Detachment*, doing all these things with greater detachment has taken a long time. Only about 500 years ago, many astronomers, for instance, were also astrologers, while chemists, including Sir Isaac Newton, were often involved in what is now called 'alchemy' (which in Arabic simply means "the chemistry"). Many of them were seeking to transmutate chemical elements, most notably making gold out of cheaper and more abundant metals. Little did they know that they were manipulating the wrong force, namely the electromagnetic force, instead of the strong force. Both forces were still unknown at that time. It has taken centuries of huge efforts and increasing detachment to reach today's knowledge and control over the rest of nature. The following example may clarify this.

> I experienced such a transition of organic chemistry from basically a cookbook science into a fully-fledged science first hand during my second year while studying chemistry in 1972. One of my lab assignments in organic chemistry was to synthesize a series of compounds called glutarimides. These are fairly basic compounds with little or no commercial value or any other social importance. My supervisor wanted to take measurements of certain chemical bonds of these compounds using the most recent technology (nuclear magnetic resonance spectroscopy).

> Because they were of little interest, no recent recipes appeared to exist for synthesizing them. So I went to the library and explored the chemical literature, which also at that time was well organized. My search took me back to the 1880s and even earlier than that. And sure enough, I came across recipes for synthesizing some of these compounds by well-known chemists. At that time, organic chemistry was not yet well understood theoretically. In doing so, I realized that in the meantime, the discipline of organic chemistry had undergone a transition from what looked like a trial-and-error cookbook approach without a clear theoretical underpinning into a well-established theoretical discipline.

Howe could we achieve greater detachment in the humanities while engaging in academic research? Surely, all academics are human beings, and doing science always involves dealing with one's emotions. Yet over the course of time, natural scientists have learned to take distance from their emotions, which usually do not end up in their research reports. Their accounts focus on the results of investigations as well as on the methods used to obtain them. Their feelings may show up in their personal accounts and histories, if they are willing to write them. A famous example of such personal memories is the book *The Double Helix* (1981) written by US scientist James Watson (1928-), which tells his personal account of how the structure of DNA was discovered in 1952-53 together with Francis Crick (1916-2004) and others. But in their scientific articles, and also in Watson's textbook *Molecular Biology of the Gene* (1970), which was part of my first-year chemistry education at Leiden University, these stories and emotions were entirely absent.

The large separation between detached academic reporting and dealing with one's emotions has become such standard behavior in the natural sciences that it is followed without much, if any, reflection even by newcomers in the field such as me. The following example may illustrate this.

> As part of my attempts to synthesize glutarimides mentioned earlier, I tried to make N-Cl glutarimide. This compound seemed never to have been described; at least I could not find any data about it. When I tried to synthesize it using an approach analogous to N-Cl succinimide, this led to an explosion. Fortunately, I had carried out the experiment in a safe and protected environment. After watching strange bubbles and fumes coming out of the glass reaction vessel through a protective glass window, I warned my supervisor. At the moment that he appeared, the explosion took place. I still remember us running away, me jumping after this huge guy like a little rabbit chasing its mother.

None of that appeared in the lab report, however (I still have it). It only offers a detached description of the chemical events that took place. That was considered the important result. Nobody took any notice of my possible emotions either as a result of this explosion – I was completely on my own in dealing with that. Such aspects were simply not part of the pursuit of academic research at that time. It also made me wonder whether such an explosion was ever reported in the chemical literature, and if not, how many researchers might have done similar things. More in general, it raised the question of what is, and is, not reported in the academic literature. I am not going to purse that subject here. But the increasing separation over the past centuries between personal experiences and academic reporting, including not reporting failures, might be an interesting line of research.

A similar distance is also noticeable in academic reports in the humanities. Yet it happens quite regularly, also in big history accounts, that such accounts are spiced up with the author's personal emotions and value judgments, such as how 'amazing' certain developments are, or who the 'good' and 'bad' actors are. In doing so, such accounts combine personal feelings and personal value judgments with academic reporting. Doing that sort of thing is now considered totally unacceptable in the natural sciences, although such statements may appear in popular science books, because that might lead to better sales numbers.

Let's return to the comparison between the natural sciences and the humanities. It does seem correct, as natural scientists often remark, that there is less solidity in the humanities, most notably a paucity of hard data or good theories. Surely, as said before, the humanities are studying the most complex aspects of nature, which do have feelings and opinions, while there are often many layers of interpretations of meanings and intentions, including many types of uncertain information, if not outright deceit. As a result, this inevitably leads to a great many layers of interpretations. Far fewer experiments are possible, while the ones that are performed are much more artificial in character. Furthermore, the numbers of 'objects,' humans, involved are usually much smaller and much more varied and complex. All of this makes statistical approaches in the humanities and social sciences far less reliable and insightful.

In addition, while studying human societies in the past or present these processes will never repeat themselves exactly. This is not unique to the humanities. In Earth science, climatology, geology, biology, and astronomy, in fact in all studies of historical processes very similar situations can be found. Yet many of those fields have developed their paradigmatic theories, while the humanities have not yet done so. And when scholars of human societies are employing certain theories, they are still divided into a great number of competing schools, as Thomas Kuhn observed more than fifty years ago.
To be sure, there have been efforts to develop general theories of human behavior. In my opinion, Norbert Elias's process sociology currently offers the best available option. But even that promising theory is still in its infancy, or so it seems to me, and much work needs to be done to turn it into a general theory of human behavior. And that work will only be done when sufficient numbers of gifted scholars will obtain positions at universities that enable them to do so and accept the results.

It is often said that in the natural sciences the interplay between empirical observations and theories leads to new empirical predictions that can serve to test the theories, while this would not be the case in the humanities. This lack of prediction may indeed exist in some branches of the humanities. Yet by employing Elias's process sociology it turned out to be possible to predict certain aspects of the past that had not yet been investigated, as some of us involved in this approach discovered at the end of the 1980s and early 1990s (for some examples, see: Spier 1994). This was a pleasant and encouraging surprise.
It seems to me that by further developing this theory, there is a good chance that its predictive power will be enhanced as well. In the Epilogue to his book *Guns, Germs and Steel* (1997), US scholar Jared Diamond made a very similar point.

Why would there be less detachment in the humanities?
The main reason why there are no general theories yet within the humanities, following Elias's argument, is that there has not yet been enough detachment within many of these disciplines. Why not, one wonders?

First of all, there seems to be a resistance among certain sections of the humanities against using theories, because their objects of investigation are deemed so complex that theories simply would do them sufficient justice. Such concerns are understandable but may not be warranted. If one does not try, one will never succeed. Surely, such general theories will only emerge as a result of a long process of trial and error, including a great deal of scholarly discussion. And because a considerable number of grand theories, such as Marxism and Social Darwinism, were proposed that did not work very well, this has soured the appetite of many practitioners in the humanities for trying again.

Yet even though historians and others may reject theories or sparsely use them, they must have them somewhere in the back of their minds. If not, how could these scholars decide what is important to mention and what is not? How would they make those choices out of the zillions of potential data? In my view it is better to put one's theoretical cards openly on the table, so to speak, so that they can openly be discussed. Especially among sociologists but also among some social anthropologists and economists, theories are far more accepted. Yet also in these disciplines a great many schools exist, while few attempts, if any, are made to unify them.

The theory-driven approach offers great advantages, not least that it makes clear what is at stake and what its strengths and potential weaknesses are. Furthermore, it can show more clearly which information is lacking (which is usually by far the largest portion). If one relies on documentary studies without keeping such a bigger picture in mind, these insights may easily get lost. In other words, theories are very helpful for focusing on the bigger picture while helping to solve a great many smaller puzzles.

But as Thomas Kuhn emphasized, theories are also constraining, because they define what the legitimate problems are and, in doing so, potentially exclude other problems and questions. Any researcher would do wise, therefore, to keep one's eye open for what can be observed and reflect on it, especially when something seems to be wrong or seems to fall entirely outside of the theory employed. That is not easy. Most scientists may tend to push out such unpleasant feelings and observations, or may not see or feel them at all. Yet as a result, they may never discover something really new.

Currently, many socio-scientific theories still seem to be in their infancy. Furthermore, it may also happen from time to time that social scientists seek to adapt their data to their theories, not least by omitting data that do not fit the picture very well. This is not entirely uncommon in the natural sciences either. But in that field, it is far more common to engage in critical reflections, including self-reflections, concerning what does or does not work. Yet as Kuhn emphasized, it may be very difficult to obtain acceptance of fresh ways of understanding the world, not least because so many academics have invested their whole lives in working with the established theories, while they may be reluctant to abandon them.

In addition, it occasionally happens in the social sciences and the field of history that intuitive ideas are adopted as structuring principles or hypotheses without carefully examining them by testing them against all the available evidence and theories using strict rational thought. In other words, such intuitive ideas emerging out of direct experience are not sufficiently checked with the aid of a careful rational logical reconstruction. This may lead to rhetorically appealing arguments that, on further inspection, are not sufficiently rigorous.

It seems to me that in this respect the natural sciences are much more advanced than the social sciences and the humanities, because such natural-scientific ideas are usually much more rigorously tested before making them public, while they are thoroughly discussed after having reached the public domain. Of course, all of this may entail serious

problems of understanding each other, as Thomas Kuhn emphasized, including the willingness to understand others. But based on my experiences there can be little or no doubt in my mind that this approach is currently far more rigorously pursued in the natural sciences than in the humanities.
It seems, therefore, of utmost importance to rigorously test hypotheses equally in the humanities before launching them into the public domain. This includes: checking them against all the available information; engaging in further investigations to find evidence in support of, or undermining, the hypotheses; and engaging in efforts to predict the past elsewhere. In biology, Charles Darwin's famous book, *On the Origin of Species* (1859) offers an excellent example of such a scrutinizing self-critical attitude. It would be great, or so it seems to me, if this type of approach would also become dominant within the humanities as a whole.

Surely it is not always necessary to explicate the general theories - no chemist or physicist would do that either in their more specific investigations. But it does seem important to have such theories in the back of one's academic mind, so to speak, and to share them with others as soon as someone asks for them. That is what natural scientists do. Having a theory in the back of one's mind and regularly consulting it while doing the research may also help to improve the quality of the analysis by structuring it, and by using it as a heuristic device.

It has also struck me that in the natural-scientific literature the reporting of fresh results always starts with a summary of previous knowledge. In doing so, it provides an outline of what is new and what is already known. Although the mentioning of previous knowledge is certainly not absent in the social sciences and the humanities, it seems to me that especially articles in journals often lack this aspect (including this article), while books may sometimes not sufficiently do so either.
It is surely easier to do so in the natural sciences than in the humanities, because they are so much more structured and well organized. Yet from time to time claims of originality in the humanities appear not to be not sufficiently backed up by overviews of previous knowledge that clearly was available. I cannot be sure about why this is happening. Surely, the materials are more spread out over disciplines and sources and as a result much more difficult to trace and access. But we now live in a time in which a great deal of such knowledge is almost instantly available. This offers excellent chances within the humanities to set the record straight. Doing so would greatly improve the chances of authors building upon each other's knowledge, and thus help to achieve a more systematic accumulation of academic knowledge and, in consequence, more progress in the improvement of our academic insights.

Furthermore, it happens from time to time that social scientists employ theories in which the personal political and/or social preferences seem to be percolating. Although it will obviously be impossible to take full distance from one's own socio-cultural and personal background, it seems desirable to me to try to avoid such a bias as much as possible. This requires a great deal of self-reflection, detachment, and discussion, and also a willingness to allow certain insights that may not correspond with one's own personal preferences. This can be a painful process, as I have experienced myself. But by allowing this to happen, the analysis may become better, that is: more reality congruent, as Norbert Elias called it. To be sure, all reconstructions of reality and its past will always remain representations of reality. In consequence, they will always be open to discussion and further improvement.

As mentioned before, I think that Norbert Elias's process sociology, explained in his book, *What is Sociology?* (1978), offers a good example of a general theory that seems to be as free as currently possible from personal political or personal value judgments, other than that it appears to be a good theory for analyzing human behavior. And it seems like that because it seems to work in practice. Elias used it, for instance, to explain changing standards of behavior and state development of what became France (1978b, 1982, 1983). I myself used it to analyze religion and politics in Peru during its entire known history at all levels of society (Spier 1994-95). Interestingly, my analyses were readily accepted and discussed at the University of Cusco (UNSAAC) in 1996 and 1997 when I went there to present them. Apparently in Cusco there was some cross-cultural acceptance of these ideas for understanding their own reality, which is a good sign, or so it seems to me. Other scholars have used Elias's theory for engaging in a great variety of social studies.

Yet a great deal of theoretical work still needs to be done to turn Elias's process sociology into a successful theory of human history. But the potential seems to be there. What is needed now, I think, is to compare the existing studies and discuss what has been achieved and what is still lacking. But if a better theory appears, that would be great as well. Surely, the goal should never be to stick to one particular theory, but instead to look for the best possible theoretical explanations of our common past.

Engaging in academic research

Because practitioners of academic research use this method to achieve what they see as the best possible representations of the world and its past in terms of underlying forms, at least for certain purposes, the scientific enterprise as whole is limited as a result of the first three requirements mentioned above. The world of direct experience, by contrast, including all the feelings and reactions that it engenders, is not limited by these requirements and is, in consequence, much larger in scope. Furthermore, most people on this planet are not scientists, even though they engage in certain types of thinking in terms of underlying forms, while no single scientist is only a scientist all the time and never more than that. In other words, as a result of the requirements mentioned earlier, the results of academic research are by necessity much more limited than the world of direct personal experience.

In socio-scientific and historical accounts this distinction is often not very clearly drawn. Surely, it is much more difficult within the humanities to take distance from emotions, not least because the objects of investigation have them and may show them to you, whether you like them or not. Lifeless nature as studied by astronomers, physicists and chemists do not have feelings. For biochemists and biologists, however, this may turn into a problem as soon as they start to investigate living things that do have feelings. Another personal example may illustrate this.

> As part of my biochemistry study I had to test the brains of rats for certain substances. This was a demonstration experiment. For doing so, these animals needed to be killed. Because of this, and because of possible students' sensitivities, we were given the choice of opting out, which I did, because I could not see any reason for killing animals to do experiments that were only meant to be a demonstration, while they would not yield any new and useful knowledge. I still remember the resentment I felt about this, while I usually felt no such resistance in experimenting with lifeless nature, or with microorganisms and plants. I did feel apprehensive, though, about using dangerous chemicals, including radioactive tracers. Yet in such cases we were not offered an opt out, but were advised instead to use protective measures (which were not always used).

I do not know what my fellow students thought or felt about these things. I do not remember any discussions with any of them concerning this issue. But in retrospect I realized that this was the borderline where such specific ethical problems began, namely as soon as the objects of investigation have feelings. This does not mean to say that studying lifeless nature does not entail ethical problems – it surely does, because of the effects it may have on the world. That is what all sciences have in common.

But it is different when the objects of investigation have feelings, and even more so, when they can talk, and talk back to the investigator. That may be why, I think, biologists and biochemists tend to downplay the abilities that animals have, especially in terms of consciousness and suffering, of feeling pain and anxiety, because recognizing such things might upset their own feelings.

While atoms and molecules, stars, planets, and moons do not have feelings, humans do, and they are able to express them. This inevitably implies that social scientists will have to be more involved, simply because they need to interact with their objects of investigation (which are rarely, if ever, called as such). This interaction, including the need to understand other people, requires a considerable degree of empathy, including with people whom you may find morally problematic. This empathy may be the most important skill needed to engage successfully in social science. For if the academic researcher were not able to understand all people involved in the investigation, how would she or he be able to know what was going on? At the same time, the scientific method requires as much detachment as possible. As a result, social scientists need to learn to combine both involvement and detachment as part of their academic skills.

This combination of involvement and detachment in the humanities is much more demanding than any of the tasks faced by natural scientists. Surely, also these scholars need a great deal of involvement in their work, while they may be dealing with dangerous substances, procedures, or social and ecological circumstances that can all raise important ethical questions. Such researchers may also have to cope with culturally challenging situations. But the additional involvement of dealing with fellow humans as objects of investigation is entirely lacking. As a result, the continuous switching between involvement and detachment for social scientists during their empirical research is much more challenging, while it raises a range of additional ethical questions that will need to be addressed one way or the other, simply because one is investigating fellow human beings who have their own interests.

Especially the challenges of participatory research as a cultural anthropologist are unique, or so I think. While living in one's own research field day and night, the investigator has to consequently try to put oneself into the shoes of a great variety of other people who are culturally different. The aim is to present an analysis of the dynamics produced by how all these people interact with each other. Yet the researcher may not like some of them, while some of them may not like each other either, or they may not like the investigator. Furthermore, many of them may be very poor. (Wealthy people are usually far less accessible to cultural anthropological investigation – for historians, interestingly, the situation is virtually the opposite; it is mostly the wealthy and powerful people who have left written documents or statements). These poor people may well see the researcher as a potentially welcome resource.

As a result, such situations introduce all kinds of tensions and biases which are often not made explicit. Doing all of this in continuous interaction with the people under investigation, including their reacting to and commenting on the researcher and on the investigation in progress, while at the same time seeking to take as much academic distance as possible, has been by far the most challenging academic enterprise I have ever undertaken.[3]

Furthermore, by entering into social situations that are different from one's own experiences, and by investigating them as thoroughly as possible, social scientists may become acutely aware of many aspects of their own culture that they may have taken for granted until that time. As a result, their personal socio-emotional makeup may undergo considerable change, including finding it hard to operate within their 'own' societies again, because nothing may seem 'natural' anymore. As Tineke Luhrnman, who went through such experiences herself in Ecuador and Peru in 1985-1986, expressed it many years ago: "After one has lived in another people's dollhouse, one becomes acutely aware of the fact that one lives in a dollhouse oneself as well." Natural scientists rarely, if ever, seem to go through such experiences.

As a result, it seems to me that doing social science research, most notably longer-term participatory observations within a cultural setting that is different from one's own, places far greater demands on a wide variety of skills than any other form of science. The rewards have been equally great, though, in terms of what can be learned about that particular society; about oneself; one's 'own' society; and about life more in general. All of this presents major reasons for why it has been more difficult in social science research to take sufficient academic distance, and as a result why there is not yet a general theoretical paradigm of human history.

Final words

If we consider feelings as belonging to the domain of direct experience and academic thinking as belonging to the domain of underlying form, our daily emotional expressions fall outside of the strict academic research method, other than that they can become an object of investigation. Yet at the same time emotions thoroughly guide all these investigations. The same is the case for norms and values, including ethical judgments such as 'good' and 'bad,' 'pretty' and 'ugly,' none of which can be clearly defined from an academic point of view. To be sure, personally I find all these aspects of great importance. But they are simply not part of the academic toolbox of terms that can be used to analyze situations in academic ways, even though they play a major role in the academic enterprise as a whole.

Many people find this difficult and, in consequence, may seek to include an emotional vocabulary or social actions into the academic toolbox. But by doing so, the notion of academic research and the resulting knowledge as we know it today would be destroyed, simply because in that case virtually everything people do could be called as such. And as soon as that were to happen, these analytic terms would lose their specific meaning.

In my opinion, all students of the humanities, in fact all academics, will have to live with the fact that the academic research method will always yield a limited view of reality. Whether one finds the resulting representations of reality valuable or not is based on personal value judgements. But I hope to have shown that the general principles governing academic research are in principle the same all across academia.

I personally hope that there will be more room in the future within the academic world for researchers from all disciplines, not only to write down their academic analyses but also to reflect on their personal experiences that have led to these results, because that would enrich our insights of how the process of academic research works. Combining those two aspects in an equal

3 A report of and some reflections on my Peruvian fieldwork experiences can be found in: Spier 1986 (in Dutch) and in: Spier 1995, p. xiii-xviii.

way was perhaps the major thrust of the work of Alexander von Humboldt (1769-1859). One can argue about how successful von Humboldt and his followers have been. But it seems to me that doing so in whatever ways that appear to work would considerably enhance our views of how academic research works in practice. And that may help us to improve our understanding of the results of academic research, even though these results themselves must be based on nothing else but empirical evidence and underlying academic thinking.

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A Little Big History of Iberian Gold:
How Earth processes concentrated the precious metal that played a critical role in the history of Spain and Portugal

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ABSTRACT
We present a "little big history" of the gold that either was mined in the Iberian Peninsula, or was brought there from deposits located elsewhere, by trade or by conquest. During Roman times, gold was extracted from the Peninsula itself. In the Middle Ages, gold was brought across the Sahara from very rich near-surface occurrences in West Africa. After the discovery of the New World, Colombia was the most important source of gold entering the Peninsula. Each of these gold-bearing regions has had a different geological history, and in each one, gold was concentrated by a variety of geological processes. The West African gold dates back to fairly early in Earth history, about 2 billion years ago, and resulted from closure of an ancient ocean basin. The Iberian gold is related to the continental collision that produced the Appalachians and their Variscan continuation in Europe, while assembling the Pangea supercontinent. The Colombian gold is associated with the subduction under South America of the Pacific Ocean crust that has produced the Andes. For each of the three regions we present a database of historical and active gold mining areas, and we summarize this information in maps. The ways in which Earth concentrates gold are the subject of much geological research, and we give a brief introduction to this remarkable topic, hoping that big historians will go beyond Carl Sagan's statement that "We're made of star-stuff," and will recognize that "We're made of star-stuff, concentrated by Earth."

I. INTRODUCTION

One approach to the study of big history is to take some feature of the human situation and trace the history, from the beginning of the Cosmos, which has led to this aspect of the world we live in. Esther Quaedackers pioneered this approach, and she calls such a study a "little Big History."

Of the four regimes of big history — Cosmos, Earth, Life, and Humanity — different ones are of differing importance in different little big histories. Most little big histories will begin with fairly similar cosmic histories, because everything in big history has obeyed the same laws of physics, set up early in the Big Bang, and the chemical elements of which our physical world is constructed were fashioned by the same stellar processes (with differences however for light and heavy elements).

Little big histories begin to turn complicated in the regime of Earth history, because the long and complex history of our planet has constructed very different geological conditions in different parts of the Earth. The very young basalt volcanic rocks of Iceland, for example, which erupted where brand-new oceanic crust is forming, bear no resemblance whatsoever to the very ancient and complicated, cycled and recycled, geology of Australia. With our backgrounds in geology and geophysics, this is the part of big history that is most familiar to us. Little big histories become seriously complicated in the regime of Life history, and overwhelmingly so in that of Human history.

In this paper we present a "little big history" of gold in the context of Iberia. This large peninsula, now shared by Spain and Portugal, has had access to copious amounts of gold for most of its history, from pre-Roman and Roman times until the independence of the former Iberian colonies in the New World about two centuries ago. This has had a major influence, for good or ill, on the economic, social, and political history of Iberia, and contrasts with other regions lacking this resource, such as the Low Countries or Italy.

We're made of star-stuff, concentrated by Earth

In addition to our specific focus on the gold that was discovered in or brought to Iberia, we have a much broader point to make in this paper, one which is important for big historians to understand. Most big historians now recognize that all the chemical elements heavier than hydrogen, helium and lithium were produced in stars and scattered through the galaxy as the result of supernova explosions. This essential piece of understanding is encapsulated in Carl Sagan's statement, "W*e're made of star-stuff.*"

But for geologists like us, that statement, although true, is incomplete. The scattered atoms and the dust grains made of silicate minerals and iron in interstellar space are too dispersed to be of any use to humans. The elements we are made of or that we use have been concentrated in a large variety of processes that go on either inside or at the surface of the Earth (Alvarez, 2016, Ch. 3). So we would amend Carl Sagan's concept to a form that big historians should embrace, and stress that:

"We're made of star-stuff, concentrated by Earth."

In this paper we will show that the gold that affected Iberian history was concentrated in a variety of different geological ways, and these are just a sampling of Earth's remarkable virtuosity in forming rich gold deposits of many kinds. This kind of little big history could be written for any of the other chemical elements, or for rocks like limestones or granites, or for petroleum and other fossil fuels. This means that the range of Earth processes that have benefitted humanity is too great to be understood in full depth and breadth by anyone, including individual geologists, but we hope our study of Iberian gold will help big historians appreciate the critical role that Earth has played in setting up the human situation.

II. GOLD IN THE HUMAN HISTORY OF IBERIA

To provide a focus for the very large, complicated, and controversial topic of gold geology (Goldfarb, 2001a, b; Goldfarb *et al*., 2010), we present our little big history of gold in the context of Iberia. During the past two millennia, the gold of Iberia has come primarily from three sources — Iberia itself, the West African Sahel, and Colombia. To keep this treatment manageable, we will not consider gold that might have entered Iberia from other sources available to the Roman Empire, such as Dacia (modern Romania), the Egyptian-Arabian-Nubian region, or Wales. The gold from the three regions above was delivered to Iberia in four different ways during four historical episodes:

Gold from Iberia

Some of the earliest known gold artifacts from Spain come from Asturias in the northwest of the Peninsula, dating from the early Chalcolithic (Blas Cortina, 1994), and are currently under study. We also have the Pre-Roman Treasure of Arrabalde, found near the later Roman mining site of Las Médulas (Perea and Rovira, 1995). Pre-Roman gold is also known from the realm of the Phoenicians and the contemporary native Kingdom of Tartessos, in the south of Spain. In Extremadura, in south- central Spain, as the site where at least some of this gold was originally collected is now known, the chemical details of natural nuggets match those of the Tartessian Treasure of Aliseda (García-Guinea *et al*., 2005).

Abundant gold paleoplacers —or ancient alluvial ore deposits— in northwest Iberia were probably exploited by artisanal mining in pre-Roman times. This area subsequently became a major source of gold for the Roman Empire. Las Médulas, where Roman engineers and miners recovered gold from old, consolidated sedimentary deposits, must have been an environmental disaster at the time, but today is a landscape of colorful beauty that has been designated a UNESCO World Heritage Site (Fig. 1). The Roman mining system used at Las Médulas, aptly named *Ruina Montium*, was described by Pliny the Elder (transl., 1952). A

Figure 1. Las Médulas (León, NW Spain). This UNESCO World Heritage landscape is an ancient gold mine from Roman times. Photo courtesy of Bernardo López Santamaría.

newly discovered site of large-scale Roman extraction of gold from river gravels is in the Valdería, near Castrocontrigo (Justel-Cadierno *et al*., 2014; Fernández-Lozano *et al.*, 2015). Both of these sites are within 100 km of the city of León, a name deriving not from "lion," but from "legion," for this was the headquarters of the Roman legion charged with protecting these critical sources of gold. Production evidently tapered off or ceased after the Roman decline and the Germanic invasions eliminated the technical expertise and infrastructure necessary for intense gold mining. We also briefly consider the gold-bearing region in southwestern Iberia, whose geological origin is quite different from that of northwestern Iberia.

Gold from West Africa

After a few centuries in the Early Middle Ages in which gold was less important in Iberian history, the Islamic conquest of the 8th century

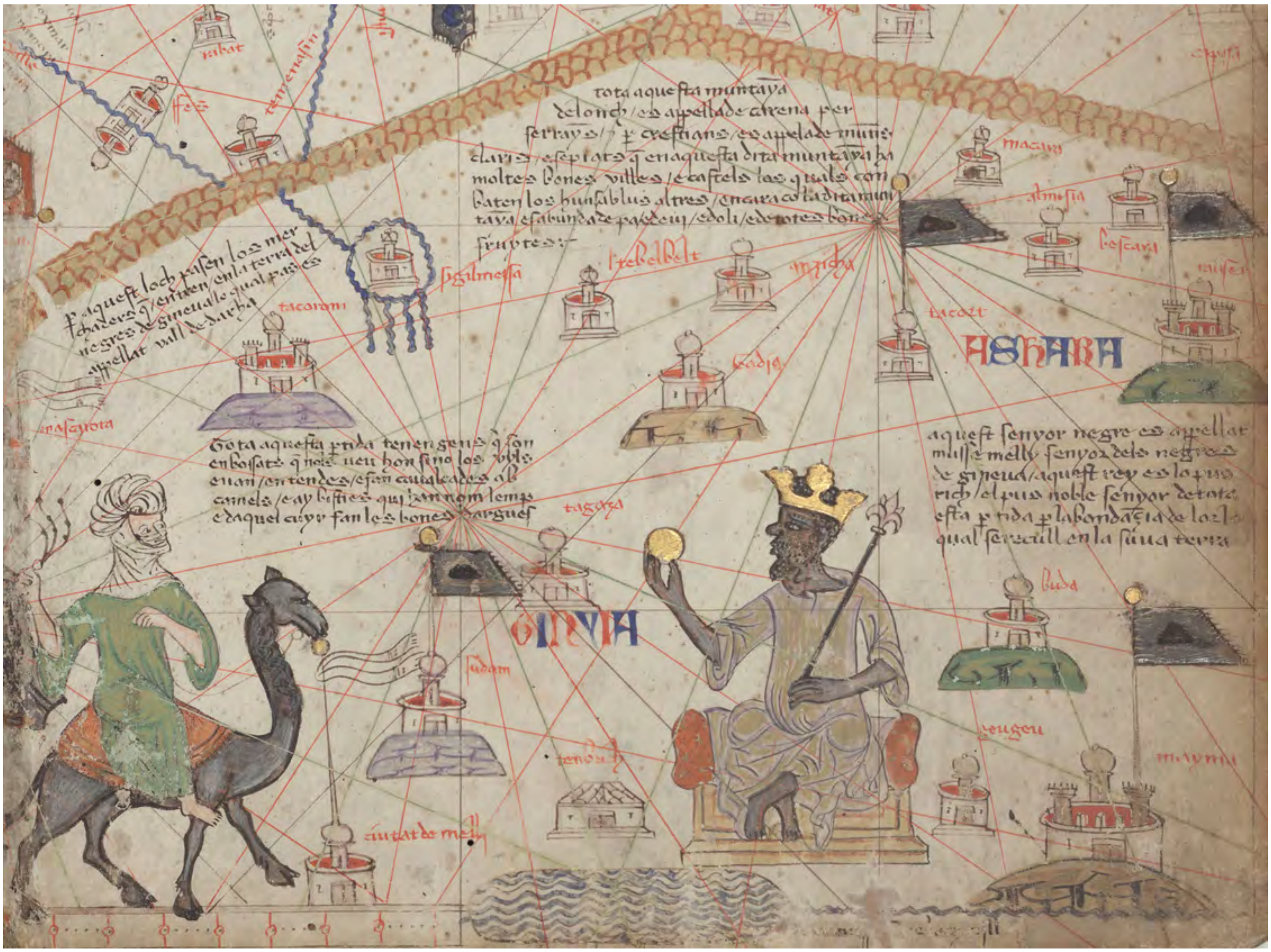

Figure 2. Mansa Musa. Catalan atlas about 1525 ACE, with the image of the King of Mali, Mansa Musa, shown with the gold that made his kingdom so wealthy (attributed to Abraham Cresques, about 1375, https://upload.wikimedia.org/wikipedia/commons/7/7a/Catalan_Atlas_BNF_Sheet_6_Western_Sahara.jpg)

brought contacts with Morocco. This eventually led to an influx of gold into Iberia via the trans-Saharan caravan trade from abundant sources in sub-Saharan West Africa. In this long-enduring caravan trade, Arab merchants exchanged salt, extracted from deposits at Taoudenni, in the middle of the Sahara in modern Mali, for gold harvested from rich placer deposits called Wangara, probably along the Senegal River (Bovill, 1968). Much of the gold eventually reached Islamic Iberia, in exchange for its sophisticated manufactures.

As the strong Islamic control of Iberia, centered at Córdoba, faltered after the 11th century, much of the African gold reaching the Islamic parts of the peninsula was extracted by militarily strong Christian kings, as the tribute called *parias*, from the weaker kings of the Islamic successor, *taifa* kingdoms. Christian kings like Fernando I (1037-1065) and his son Alfonso VI (1065-1109) of León-Castile gave huge gifts of gold to the French Benedictines, and these riches largely funded the cultural and artistic flowering of Cluny (although Fernando's gifts have recently been questioned: Pick, 2013).

By the 14th century it was well known that the kingdoms of the Sahel were enormously rich in gold, because of the pilgrimage (1324-1325) of the King (or Mansa) of Mali, Musa I (c. 1280-c. 1337), to Mecca, in which he distributed huge amounts of gold in Cairo (Fig. 2). The search for a way to outflank the Arab-controlled trans-Saharan gold caravan may have been one of the motivations for Prince Henrique of Portugal ("Prince Henry the Navigator") to begin the Portuguese exploration along the west coast of Africa in the early 15th century (Russell, 2000). As a result, by the 15th century the Portuguese had reached the African gold region by sea, founding the trading center of Elmina in 1482, on the coast of modern Ghana, within 100 km of rich gold-producing regions (Leitão and Alvarez, 2011).

Gold from Colombia

After the capture by Castile, in 1492, of Granada, the last Islamic kingdom in Iberia, African gold could no longer reach Spain in large quantities by the trans-Saharan route. However, in that same year, the discoveries of Columbus brought two whole new continents to the attention of

Figure 3. Pre-Columbian boat sculpture as an example of Muisca art in Colombia; the gold probably came from placer deposits in riverbeds. (Votive figure. Cordillera Oriental – Muisca. 600 CE – 1600 CE. 10.2 x 10.1 x 19.5 cm. Museo del Oro Collection – Banco de la República. Colombia. Photography by: Clark M. Rodríguez.)

the Spanish, who rapidly undertook exploration, one major goal of which was to find resources of precious metals. Truly enormous quantities of silver were discovered at Potosí in Bolivia (1545) and at Zacatecas in Mexico (1546), while the most abundant gold resources were found in Nueva Granada, now Colombia, which seems to have been the most richly endowed gold province in Andean South America. Gold placers were exploited in much of Colombia, and additional gold was taken from pre-Columbian tombs. The wonderful gold ornaments in the Museo del Oro in Bogotá (Fig. 3) give us an idea of the artistry of the goldsmiths of the Muisca (Chibcha-speaking) and related peoples.

The rich streams of New World silver and gold were funneled into Spain in early colonial times, funding the Habsburg wars against the Protestants in Europe, and causing waves of inflation that spread from Seville all over Europe — the so-called "Spanish Price Revolution." This last source of gold and silver entering Iberia dried up after the Latin American Wars of Independence in the early 19th century, ending perhaps 3,000 years of Iberian gold. But it is interesting to note that the Spanish and then the Mexicans controlled the coastal belt of present-day California until 1846, unaware of the vast gold resources that would be discovered in the Sierra Foothills, just to the east, in 1848.

III. HOW DO GOLD DEPOSITS FORM?

Almost any little big history that involves a physical aspect of the human situation — from a water glass, to a human being, to a city — must ask about the origin of the chemical elements of which it is made. This is well understood by many big historians, but what is less appreciated is that we must also ask about how each element was concentrated and made useful.

In most cases it is the Earth that has done the concentrating, through a wide variety of processes that have acted slowly over long periods of time (Brimhall, 1987, 1991). The production of natural deposits of each element thus has a history and is a vital part of big history. In this section of our paper we aim to make the origin and history of gold deposits understandable.

We have found it most effective to do this in the form of a narrative, presented as a sequence of questions. Some of the questions have answers, but others can only be answered partially, or in the form of other questions, for these are topics of active geological research. Except for the first three, our sequence of questions moves from the familiar surface of the Earth downward into the inaccessible interior of the planet.

Question 1: What is the ultimate source of gold in the Cosmos?

Q: Cosmologists now understand that at the end of the Big Bang, during the Dark Age, before the first stars began to shine, the Cosmos was made of hydrogen, helium, and traces of lithium (ignoring dark matter). How did the other 90 or so elements come into being?

A: Many big historians are familiar with the recognition that the other elements were made in stars, as by-products of the nuclear reactions that make the stars shine or, for many elements heavier than iron, during the stellar collapse that produces a supernova explosion. Gold is one of these r- (rapid-) process elements (Cowan and Thielemann, 2004), both formed and dispersed by supernovas. This understanding of nucleosynthesis has become part of the canon of big history, identified as Threshold 3, "The Creation of New Chemical Elements," in the textbook of Christian, Brown, and Benjamin (2014). In a broader sense, it is now recognized that matter has evolved during the unfolding of big history (Garzón-Ruipérez, 1994; Tolstikhin and Kramers, 2008).

Question 2: What is the ultimate source of gold in the Earth?

Q: Carl Sagan's "star-stuff," the product of many supernovas preceding the formation of the Earth, was dispersed through interstellar space and was a mixture of many different elements. How did Earth acquire its gold?

A: A detailed answer to this question would take us far from our subject. For a brief review, see Alvarez (2016, Ch. 2). But a critical point for understanding gold is that Earth is dominantly composed of four elements — magnesium, silicon, iron, and oxygen (Mg, Si, Fe, O) — which are concentrated in Earth first because they were relatively abundant in the solar nebula, and second because they make solid mineral grains, too heavy to have been blown out of the inner Solar System by the strong solar wind of the young Sun.

As Earth accreted, the growing planet must often have been largely or partly molten because of the heat of large impacts, and dense iron sank to the center to make Earth's iron core, probably carrying along most of Earth's gold, which is a "siderophile" element, easily absorbed by hot or molten iron. The other major elements — magnesium, silicon, and oxygen — went into making the Earth's rocky mantle, which we can think of as composed of minerals like olivine (Mg_2SiO_4).

A second critical point is that when Earth was almost completely accreted from solid grains and gas in the solar nebula, its growth was interrupted by a giant impact of a body probably about the size of Mars. This off-center impact tore away a substantial fraction of the Earth's mantle, which ended up as the Moon, orbiting the Earth. But the accretion of smaller objects onto the Earth continued, and they added what is called the late veneer.

Our current understanding is thus that Earth differentiated early and quickly into an iron core, surrounded by a rocky mantle that makes up about 90% of the Earth by volume. The other first-order component of Earth is its crust, richer in silicon and oxygen, and poorer in magnesium, than the mantle. In contrast to core formation, the crust has come into being slowly and gradually through the whole of Earth history. It is of two kinds: Oceanic crust forms by sea-floor spreading at mid-ocean ridges, lasts perhaps a couple of hundred million years, and then sinks back into the mantle at subduction zones; oceanic crust is ephemeral. Continental crust on the other hand, being more buoyant, generally does not subduct, but continues to float on top of the mantle, although it is subjected to repeated cycles of mountain building, becoming more and more complicated through time. To our knowledge, most of the gold that has been successfully mined is in the continental crust, although there are also very important gold deposits that formed on oceanic crust but are now found on the continents after accretion.

Question 3: How can we understand how gold has been concentrated?

Q: Over its 4.5 billion years of history, Earth has operated like a giant chemical processing plant, taking chemical elements that were all mixed up and dispersed, and gradually concentrating and refining them. Gold, for example, has been concentrated and refined by Earth in a variety of ways, which involve geology, chemistry, and physics. How can scholars and scientists who are not geologists acquire a broad, clear understanding of this important but complicated aspect of Big History?

A: By restricting ourselves to the three regions that supplied gold to Iberia in historical times, we make the topic more manageable. The three regions are geologically completely different, so we get a sense of the variety of processes at work. It might have been logical to begin our study of gold in the Earth's core and to follow it upward, ending with economic gold deposits in the crust. However, we have chosen to start at the more familiar surface and work downward.

Question 4: The easiest gold to find and mine is in placer deposits. How do placers form?

Q: In many gold-rich regions, gold can be found as nuggets and as smaller grains, within the sand and gravel sediments of rivers — both modern rivers and ancient ones — often concentrated at the bottom of the river sediment. These secondary, or "placer" deposits are relatively easy to mine, and were the first to be exploited in all three of our regions — in ancient times in Iberia, in mediaeval times in West Africa, and in pre-Columbian and Spanish-colonial times in Colombia. How does gold come to be concentrated in placers?

A: Sedimentary grains of gold are first eroded from some older rock, commonly from gold-bearing quartz veins, then transported — in this case by running water, and finally deposited as sediment. Gold has a much higher density than common quartz grains (density of 19.3 vs. 2.65 g/cm^3), so it gets sorted from quartz grains by density, accumulating at the bottom of sand bodies. The first California gold was discovered in excavations of river gravels for the foundations for a saw mill, and eventually many of these detrital grains were traced to upstream vein sources.

Sand grains in a flowing river hit against each other. In the case of quartz sand, this breaks them into smaller and smaller fragments. But gold behaves differently. Gold grains may get reduced in size, but as a malleable metal, they can also stick together as nuggets (Fig. 4a, b). Some studies (e.g., Johnson *et al.*, 2013) indicate that some bacteria excrete nanoscale gold particles and are able to concentrate gold in this way as part of their metabolism. Both of these mechanisms can build up nuggets of gold, which in rare cases can reach several pounds in weight.

Question 5: How did the gold get in veins, deposited by water, when gold is insoluble?

Q: The secondary gold in placers commonly comes from erosion of "primary" gold in bedrock, commonly gold hosted as tiny blebs of metal in quartz veins (Fig. 4c). Silica and gold have been transported in solution by hot fluid ascending from depth, often following fractures or faults, and precipitate as crystals of quartz, sometimes together with much smaller amounts of gold. The fluid carrying the gold and silica can either be relatively pure water or a mixture of water and carbon dioxide.

Gold is valued as jewelry partly because of its attractive color, but also because it does not tarnish, as silver does. The gold in a wedding ring may very gradually wear away over the decades, but it does not dissolve or react chemically. If gold is insoluble and chemically inert, then how can it be carried along in fluid rising through fractures or faults to be deposited chemically at shallower depths?

A: The answer to this puzzle is that in hot, deep fluids, gold *is* soluble, and is carried up in solution from depth — from deeper in the continental or oceanic crust. In addition to its *siderophile*, or iron-loving character, gold is also a *chalcophile* element, with an affinity for sulfur, as copper also has (Barnes and Ripley, 2016). Sulfur, among other chemical elements, will help the solubility of gold in these deep fluids. One can recognize this difference in chemical behavior under different conditions also in the fact that the gold-bearing veins are mainly composed of quartz, for quartz, like gold, is also extremely insoluble and unreactive under surface conditions (Alvarez, 2016, Ch. 3).

Like placer gold, primary gold in quartz veins and disseminated in certain rocks is of great economic importance and is mined by underground workings and in open pits in many places around the world (Fig. 4c, d). However, this "lode" mining is more difficult than placer mining because the gold is dispersed in hard rock that must be broken up into small fragments, and commonly also treated chemically, before the gold can be extracted. This was difficult in pre-industrial times, but is common today, and each of our three regions is now the focus of modern-day exploration for lode gold (see the maps in Fig. 6-8).

Question 6: What crustal environments can host gold deposits?

Q: The primary gold near the Earth's surface is transported upwards in various ways from deeper in the Earth's crust. In what kinds of geologic environments can gold-concentrating processes occur?

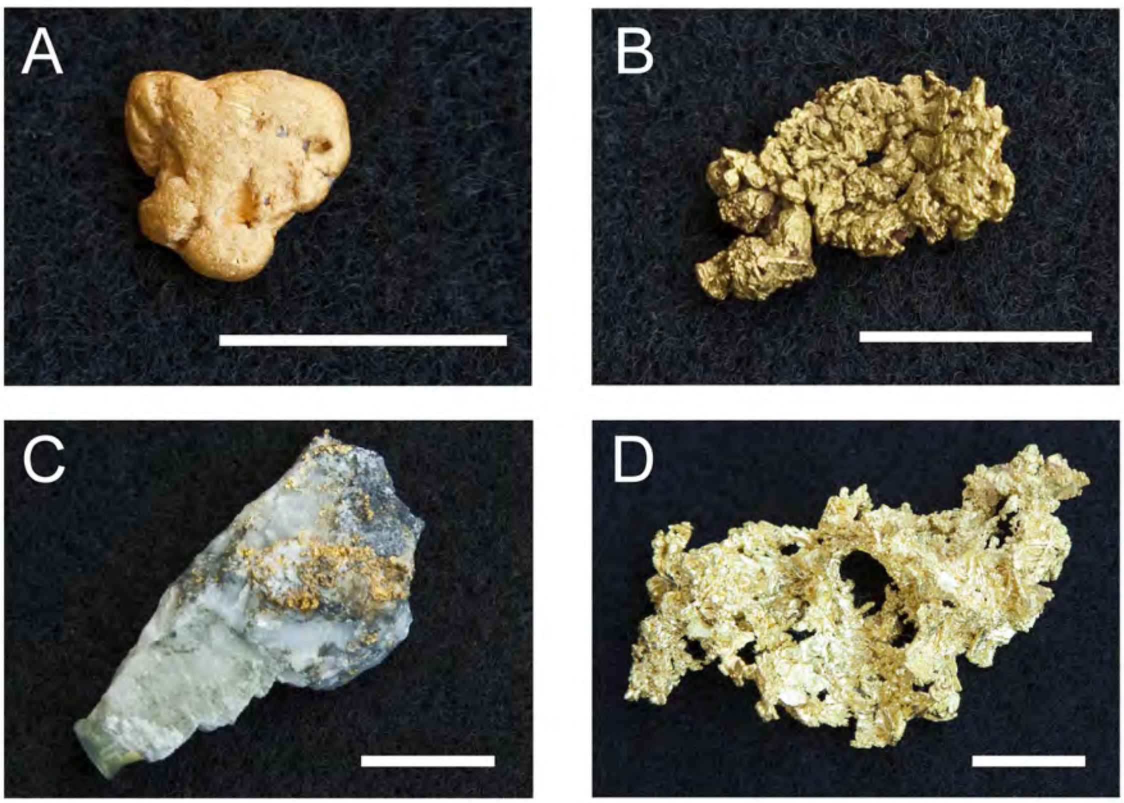

Figure 4. Natural gold samples. Horizontal scale bar is 1 cm.
a. Gold nugget from Howard River, Nelson, South Island, New Zealand.
b. Gold nugget from Galice District, Josephine Co., Klamath Mountains, Oregon, USA.
c. Quartz vein with gold from Western Lode, Level 12, Obuasi mine, Ashanti gold belt, Ghana, West Africa.
d. Nicely crystallized gold from Eagle's Nest Mine (Mystery Wind Mine), Placer Co., Sierra Foothills, California, USA.

A: We have now reached the point where the geology of gold becomes very complicated, controversial, and uncertain, so we will give only a brief synopsis of what appear to be some of the important gold-producing crustal environments:

(1) At mid-ocean ridges, two plates are moving apart, so that mantle rises and partially melts, solidifying to form new oceanic crust. Here there is a dramatic process that produces metal deposits that may contain gold. Sea water, driven

down by pressure into cracks in the new crust as it is pulled apart, is heated by contact with hot rock, expands, and rises to gush forth on the sea floor in spectacular hydrothermal vents. This hot circulating water leaches metals and sulfur out of the surrounding rocks and then deposits them in chimneys called black smokers, which may contain gold. There are spectacular images of black smokers on the web. These deposits are called volcanic massive sulfides (VMS), and some of the gold in southwest Iberia and western Colombia appears to be of this origin.

(2) At subducting plate boundaries, like the west margin of South America, thousands of kilometers of old oceanic crust may sink, dipping below the continent, and thus under continental crust, and descend into the mantle. Through these subduction processes, magmas are formed by melting of the mantle or lower crust and they rise to shallower levels in the crust. They may cool at mid-crustal or upper crustal depths to form great bodies of granitic rock, or erupt at the surface from volcanoes like those of the Andes. Gold deposits may form in this environment, such as in parts of the Colombian Andes and the Iberian Peninsula, from fluids either released from the crystallizing magmas or from surface fluids convecting around the cooling granites. Gold resources formed in these environments are typically classified as porphyry, skarn, and epithermal deposits, and many are also associated with economic concentrations of silver, copper, molybdenum, tungsten, lead, and/or zinc.

(3) Another major gold environment occurs where old ocean crust has been partly subducted and partly scraped off, or "accreted," to the edge of a continent — something like a huge car wreck in slow motion. The accreted rocks get intensely deformed and metamorphosed, magmas are produced and cool to form granites, a mountain range is driven upward, and then the continents may rebound slightly, pulling the mountain range apart in extension. Gold may accumulate in this environment, in what are called "orogenic" gold deposits (Goldfarb *et al*., 2001b, Goldfarb and Groves, 2015), using a geologic term where "oro" refers to mountains, not to gold. The gold-transporting fluid, a combination of water and carbon-dioxide, was released from different minerals as they were heated and metamorphosed during the accretion. The fluids were then focused upward along major faults during earthquake activity. Many of the Iberian gold deposits are of this type, and were generated during the Variscan Orogeny, about 300 million years ago, when Gondwana collided with the northern continents to assemble the supercontinent of Pangaea, forming the Appalachian Mountains and their former Variscan continuation through Iberia and central Europe. In addition, almost all the gold deposits in West Africa were formed this way 2 billion years ago and many of the gold deposits in Colombia were formed this way about 90 million years ago.

All three of these environments are related to plate tectonics, but two other possibilities may not be. So we treat them separately in the two following sections.

Question 7: How (and when) did gold get from the mantle into the crust?

Q: Evidently the gold in the crust must have come from the mantle, and we can ask, How did gold get into the continental crust from the underlying mantle? There seems to be no clear answer to that question because of the inaccessibility of the deep crust, but there may be an answer to a related question: *When* did gold get into the continental crust from the underlying mantle?

A: In a detailed review paper, Goldfarb *et al.* (2001b) showed that very large amounts of orogenic gold were emplaced in the latter part of the Archean (~2.8-2.5 Ga) and the early Proterozoic (2.1-1.8 Ga). This was followed by a gap in the ages of orogenic gold during the Mesoproterozoic and Neoproterozoic (1.6-0.6 Ga) before widespread orogenic gold deposits recognized in the Phanerozoic (0.6 Ga to now). Of our three regions of interest, West African gold was emplaced before the Mesoproterozoic-Neoproterozoic gap, and Iberian and Colombian gold after it. Goldfarb suggested that this episodic character of orogenic gold deposition may be related to changing heat regimes during Earth history — a topic of much interest and little agreement — as well as differences in preservation of certain crustal levels that relates to the changing regimes. One possibility is that early Earth was much hotter and lost heat by general overturn of the mantle, rather than by the organized patterns of plate tectonics.

Question 8: How did gold get into the mantle?

Q: As a siderophile element, most of the Earth's gold must be in the iron core. We also know that there is gold in the crust, where it is mined. We know less about gold in the mantle, because of its inaccessibility, but it seems likely that the mantle also contains gold, some of which has migrated into the crust. Are there ways in which the mantle could have acquired gold?

A: Broadly speaking, there are three ways the mantle could have retained or acquired gold:

(1) Some amount of gold may have remained in the mantle because of incomplete partitioning into the core during core-mantle separation (Brenan and McDonough, 2009).

(2) Some extra-terrestrial gold may have been brought to Earth by impacting objects as a "late veneer," late in the accretion process, after the core and the mantle had separated and the Moon had formed (Willbold *et al*., 2011).

(3) A small amount of gold may be carried up from the core in plumes — in slowly rising columns of hot, buoyant mantle material that continue to be active today, with the most familiar examples located at Hawaii and Iceland. It has been suggested that mantle plumes were the source of gold for at least some major gold provinces (Oppliger *et al*., 1997; Bierlein and Pisarevsky, 2008), and magma that comes not from the normal mantle, but instead from the Iceland mantle plume has been shown to contain slightly higher amounts of gold than normal mantle (Webber *et al*., 2013).

Plumes are thought to originate at the base of the mantle, where it is in contact with the hot core, and these hotter, buoyant plumes migrate upward over millions of years in a shape that resembles a mushroom (Fig. 5a). Eventually the plume 'head' reaches the surface and generates enormous amounts of volcanism (Richards *et al*., 1989) (Fig. 5b). After this burst of intense volcanism caused by the plume head, which can last for a million years or more, the plume tail forms a long-lived 'hotspot' that remains fixed in the same place for tens of millions of years, generally characterized by an active volcano or volcanic field (Fig. 5c). Tectonic plates move over this fixed plume 'tail,' and when an active volcano moves too far away from the hotspot, a new volcano is formed over the hotspot. The hotspot thus creates a chain of extinct volcanoes, leading away from the active volcano in the direction of the motion of the tectonic plate, in a way that might resemble fabric passing through a sewing machine (Fig. 5d). The Hawaiian Island chain is a perfect example, with the currently active volcano at the Big Island, and progressively older extinct volcanoes on the islands and seamounts stretching toward the northwest.

Burke *et al*., 2008 have suggested that mantle plumes originate not just anywhere on the boundary between the mantle and the core, but from anomalous regions identified through seismic studies. These regions are so deep and so small that exactly what they are remains a topic of lively debate. One appealing explanation is that these regions are the result of some material being pushed out of the core and into the mantle (Buffett *et al*., 2011). If this is the case, mantle plumes could provide a conduit to transport gold from the core directly to the crust, with very little interaction with the mantle (Fig. 5); this is a topic of active research, and there is not a general agreement among geologists.

IV. THE THREE REGIONS THAT SUPPLIED IBERIA WITH GOLD

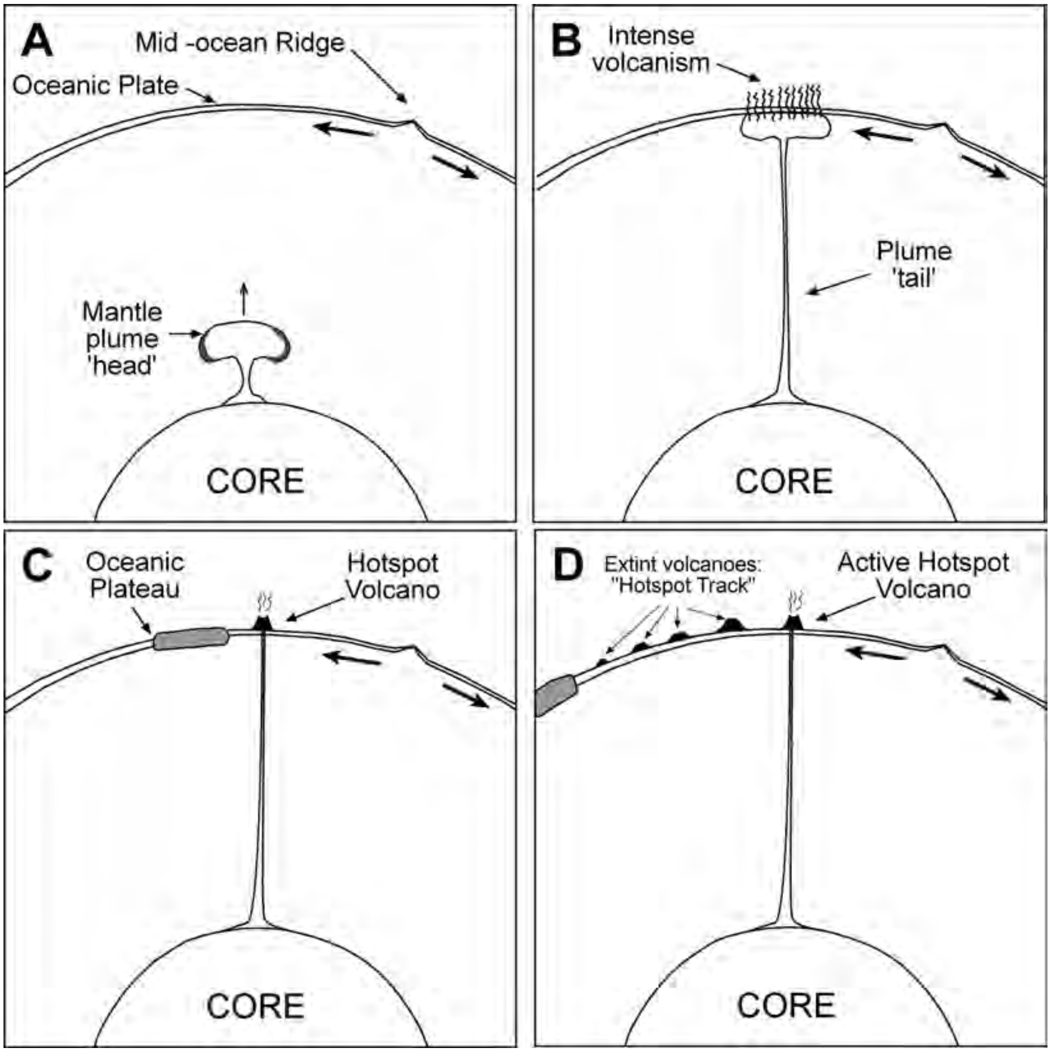

Figure 5. The evolution of a mantle plume. The base of the plume is rooted at the core–mantle boundary. Two tectonic plates separate from a mid-ocean ridge.
a. The plume rises from the core–mantle boundary in the shape of a mushroom.
b. The plume head reaches the bottom of a tectonic plate, and generates a large amount of magmatism and volcanism at the surface.
c. The plume head has entirely been erupted out or solidified on the underside of the tectonic plate, creating an oceanic plateau. The tail of the plume creates a volcano as the oceanic plateau moves away from the hotspot.
d. Each volcano at the hotspot is subsequently moved by the tectonic plate far enough away that the hotspot can no longer supply magma. That volcano goes extinct, and a new one is formed over the plume tail.

We have compiled databases for the three regions that supplied gold to Iberia, giving information about historical mining areas, where available, and about presently active gold mines and prospects. The information comes from the published literature, and from reports available on the web about modern mines and prospects in various stages of development. In many cases it has been possible to identify active mines and prospects on Bing Maps and Google Earth. We provide the databases in the Appendix, and here we summarize the distribution of gold deposits in each of the three areas in maps.

West African gold

West Africa is the largest of the three regions, and also the oldest geologically, with continental crust that was produced by

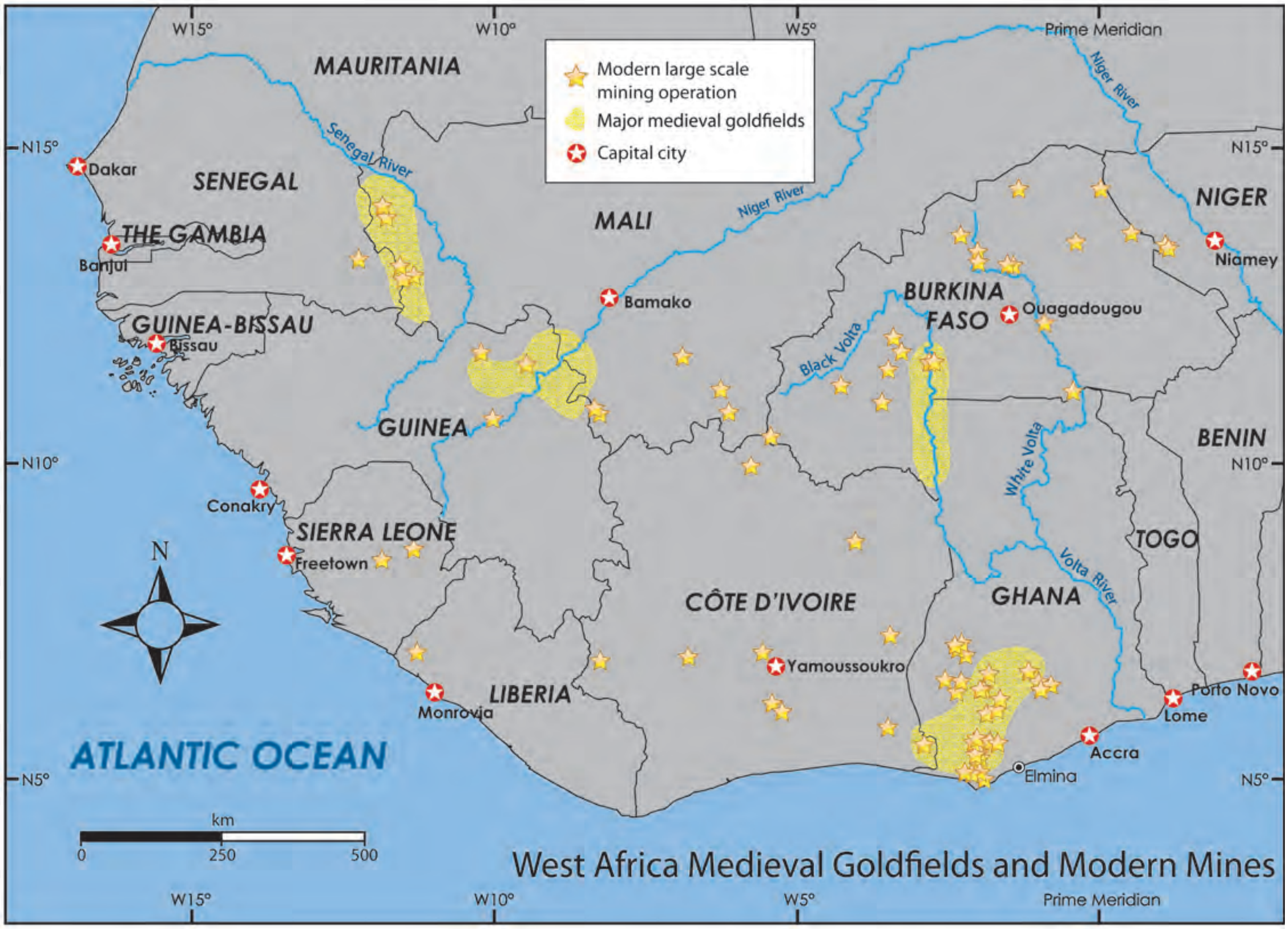

Figure 6. Gold deposits in West Africa showing historical and current mining activity. Elmina was the Portuguese trading center.

tectonic events about 2,200-2,100 Ma, in the Paleoproterozoic, around the time when our planet was beginning to acquire an oxygen-rich atmosphere and the first eukaryote cells emerged (Alvarez 2016, Ch. 7). We have compiled a database of medieval and modern gold mining areas in this region (Appendix 1), summarized on a map (Fig. 6).

Gold here is found mostly in the "Birimian" sequence, made originally of volcanic and sedimentary rocks (Smith *et al*., 2016). Metamorphism — textural and chemical change in rocks due to heat and pressure — has changed the color of these rocks to shades of green. These "greenstone" metamorphic belts are separated by granitic bodies, and this kind of granite-greenstone belt is characteristic of Archean and Paleoproterozoic regions (de Wit and Ashwal, 1997). Granite-greenstone geology is not known to be forming today, and may be the result of processes that were only active on a hotter, young Earth.

Gold in West African deposits is commonly related to faults and shear zones and is mainly found in quartz veins and disseminated in surrounding rocks of all types that may host these veins.

Erosion of those veins has led to concentrations of gold flakes and nuggets in paleoplacer deposits, which have been exploited in both medieval and modern times. It was these rich and easily exploited gold placers that made the medieval West African empires — Ghana (4th to 12th centuries A.D.), Mali (13th to 16th centuries A.D.), and Songhai (15th to 16th centuries A.D.) — so wealthy and powerful.

Iberian gold

The Iberian Peninsula (Appendix 2) is the smallest of our three regions, but gold exploitation has come from two geologically different regions (Fig. 7). Both are parts of the Variscan belt, a collisional mountain belt that crossed central Europe and, before the opening of the Atlantic Ocean, continued into the Appalachians.

One part of the Variscan belt in the southwest part of Iberia is the Iberian Pyrite Belt, an area where gold and other noble metals come from volcanic massive sulfide (VSM) deposits formed on the ocean floor by hydrothermal vents in what was a volcanically active spreading plate boundary. As discussed above, modern hydrothermal vents are the deep-sea "black smokers," some of which host abundant life despite the extreme conditions (www.youtube.com/watch?v=huTJlHMR_LE). The deposits in the Iberian Pyrite Belt are found in oceanic volcanic and sedimentary rocks of Devonian to Carboniferous age (ca. 383-323 Ma) (Gibbons and Moreno, 2002, p. 478), a time when the first seed plants, land vertebrates and primitive reptiles appeared in the fossil record.

Pre-Roman metal and gold working has been recognized in southwest Iberia dating back to Chalcolithic and Bronze Age times (O'Brien, 2015; Blanco and Rothemberg, 1981), but it was not until Roman times that substantial mining operations took place. Gold and silver were mined in the region, but they were not as important as other metals, such as copper, tin, iron, lead (O'Brien, 2015), with the addition of sulfur after the development of large open pits in the 20th

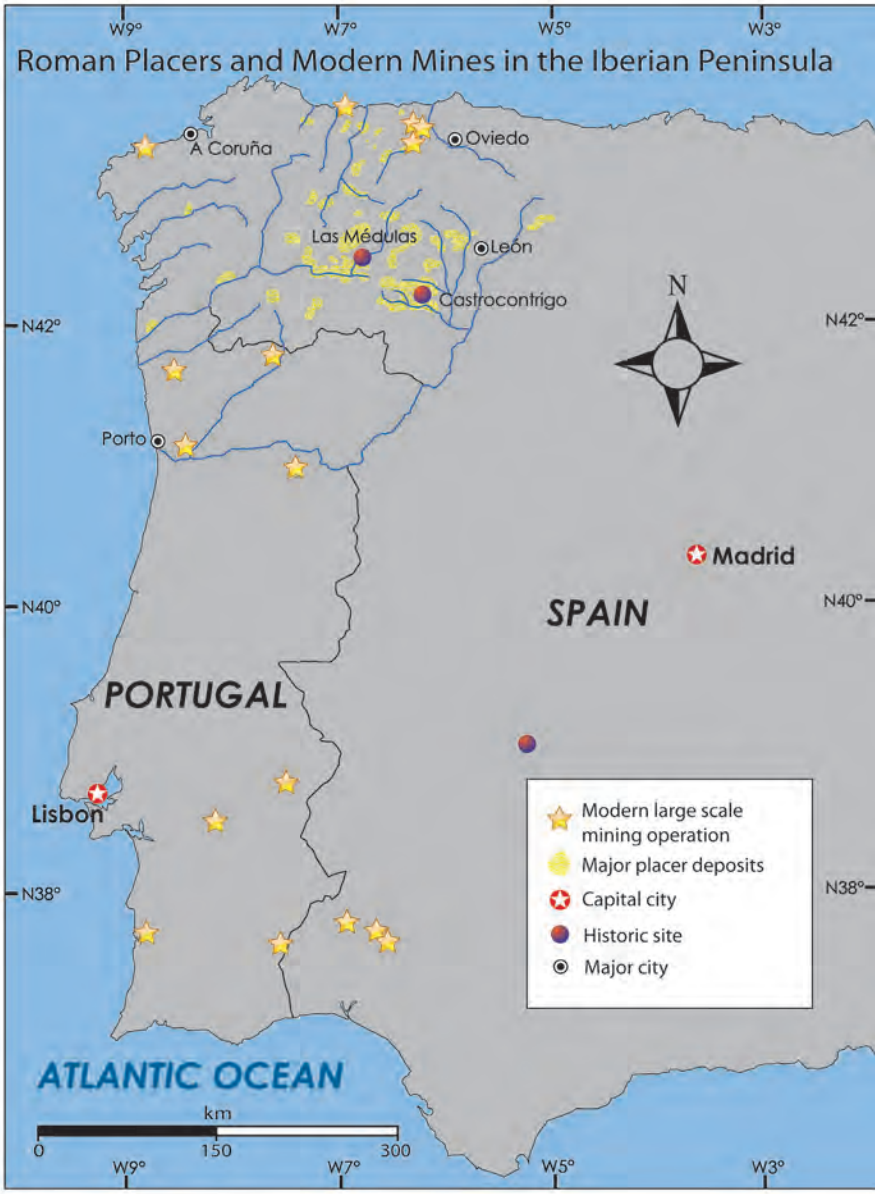

Figure 7. Gold deposits in the west Iberian Peninsula showing historical mining areas in the northwest, and current mining activity.

century (Gibbons and Moreno, 2002).

Northwest Iberia is also part of the Variscan belt. This belt was formed by the continental collision that brought together the northern continental mass (Laurentia) and the southern continental mass (Gondwana), thus assembling the most recent supercontinent, Pangea. The Variscan-Appalachian orogenic belt is geologically much younger (ca. 300 Ma) than West Africa, and most of its features are well explained by plate tectonic processes. These processes and the resulting geology are complicated, however, involving the suturing together of ribbon continents and the twisting of the mountain belt in Iberia into a doubly-curving "orocline," or bent mountain system (Gutiérrez-Alonso *et al*., 2004; Johnston *et al.*, 2013). The northwest Iberian gold deposits are of the orogenic gold type reviewed by Goldfarb *et al*. (2001b).

Colombian gold

Colombian gold is found in the Andes, a long chain of deformed rocks with volcanoes formed above a subduction zone that is carrying oceanic crust of the eastern Pacific down to the east, beneath the South American continent. The Colombian gold belt is the youngest of our three regions; it began to form during the age of the dinosaurs (Mesozoic) and the subsequent proliferation of mammals (Cenozoic), but deformation and volcanism continue to play an active role in today's Andes.

The Colombian Andes (Nie *et al*., 2010) comprise three parallel ranges, separated by the valleys of the Magdalena and Cauca Rivers (Fig. 8). The Eastern Cordillera is continental in origin, while the Western Cordillera is made of oceanic rocks. Including the complex Central

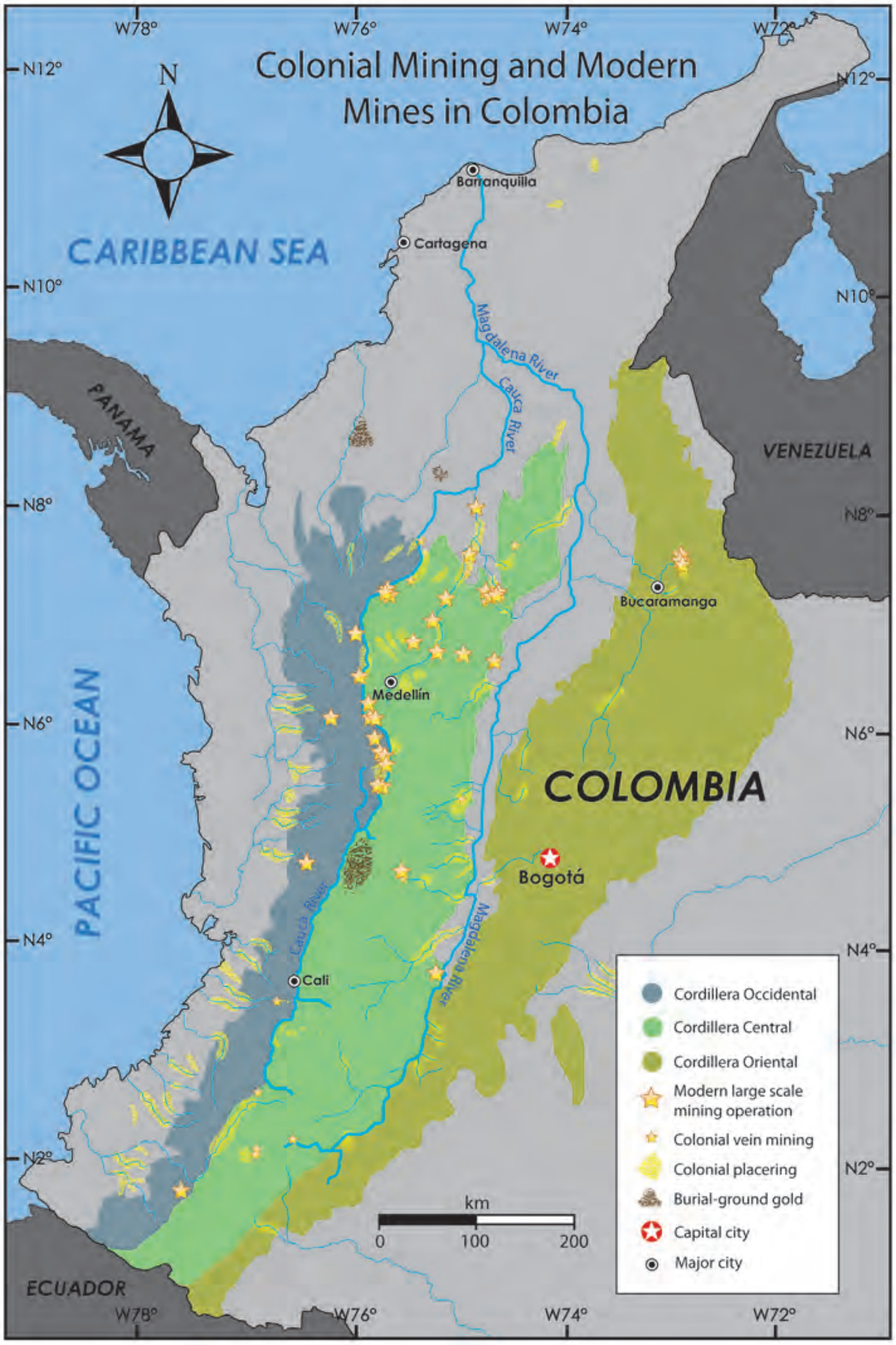

Figure 8. Gold deposits in Colombia showing historical and current mining activity.

Cordillera, surmounted by active volcanoes sourced by the descending subducting slab, the Colombian Andes record a long history of collisional accretion of continental and oceanic terranes and their lateral displacement. It is in this complicated geological environment that the Colombia gold deposits have been emplaced.

Our map and database (Appendix 3) show that Colombian gold is found in all three cordilleras, which seems surprising, considering their very different geological character. The most accessible exploitable gold in Pre-Columbian and colonial times was in placer deposits found along beds of the major rivers and their tributaries coming from the high rugged cordilleras, and in small and medium scale vein mining. Early on in the Spanish period, gold was also taken from Pre-Colombian burial grounds (West, 1952). A few mining operations of considerable scale (Fig. 8), along with smaller and illegal gold mining, are active in present-day Colombia.

V. SUMMARY AND CONCLUSIONS

Gold is an uncommon metal in the Earth and plays little or no role in biology, but humans have chosen to value it highly, perhaps because of its attractive color, its resistance to corrosion and tarnishing, and its rarity. Because of this rather arbitrary valuation, people go to great extremes to find and extract gold, to accumulate it, and to take it away from other people. Because of its accepted value, gold can be exchanged for other things that have real, intrinsic value, like food, material goods, land, and the services of other people, like workers and soldiers.

For many centuries, the countries of Iberia, for contingent historical reasons, had easy access to large supplies of gold, which was not always used for the benefit of the Iberians. Gold from the peninsula itself was the basis for the coinage of the Romans, supporting the legions that expanded and maintained the Roman world. Gold from Sub-Saharan West Africa, extracted from the petty Muslim kings after the fall of Córdoba by the stronger Christian kings, helped bring about the Christian Reconquest, and paid for much of the Cluniac artistic flowering in France. Gold from the New World, and the even more abundant silver, helped the Catholic Habsburg kings of Spain make war on the Protestants of Northern Europe.

Gold was originally derived from supernova explosions and then dispersed and diluted in the early Earth. Over the 4.5 billion-year history of our planet, many different geological processes have concentrated gold into economic deposits of many kinds. Some of these are reasonably well understood, others are enigmatic and are the subject of continuing geological research.

The ways in which Earth concentrates gold, and all the other elements we humans use, can be understood at many different levels, from the very general to the complex and subtle. We hope that big historians will recognize the need for at least a basic understanding of Earth's virtuosic ability to concentrate and make useful all the chemical elements that originally were dilute, dispersed, and quite useless.

We thus hope that Carl Sagan's memorable aphorism, that "*We're made of star-stuff*," will be supplemented or replaced by a statement that contains a deeper understanding of Big History:

"*We're made of star-stuff, concentrated by Earth.*"

VI. APPENDICES

Appendix 1: Database of historic and modern gold sources in West Africa.

Appendix 2: Database of historic and modern gold sources in Iberia.

Appendix 3: Database of historic and modern gold sources in Colombia.

VII. ACKNOWLEDGMENTS

We would like to thank Richard Goldfarb for his thorough review of a previous version of this paper. We thank Gabriel Gutiérrez Alonso for helpful information about Roman gold in NW Iberia, and Bernardo López Santamaría for the photograph of Las Médulas in Fig. 1. We also thank Robert Knapp for discussion and information about Pre-Roman gold in Spain. OGM´s stays in Berkeley in 2013 and 2016 were financed by Banco de Santander, through the International Excellence Campus of the University of Oviedo, in the framework of the excellence-mobility program for lecturers and researchers. We thank Timothy Teague for technical assistance, David Shimabukuro for general discussions of the geology of gold, and David Pedreira for photography and discussions about the geology of gold in Iberia.

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The Meaning of Human Existence. By EDWARD O. WILSON. New York and London: W. W. Norton and Co., 2014 207 pp. $14.95 (paperback).

So, what is the meaning of human existence? As it turns out, it is "the epic of the species" (p. 174). According to E. O. Wilson, in this new book, the meaning of existence is *the story itself*, the whole kit and caboodle, from our biological origins through prehistory and recorded history and on into the future.

But wait a minute, if we are dealing with physical laws, and what we can observe, measure, and test; if our guiding principle is a commitment to empirical evidence and scholarly methods; if science "is totally committed to fact without reference to religion or ideology" (p. 44); then how can the meaning of human existence derive from our understanding of the future about which we have no evidence whatsoever?

Wilson swats away this pesky problem by flattening out the meaning of "meaning" to fit his conclusions, while at the same time expecting anyone who reads the book of nature in a "scientific" manner to come to the exact same conclusions as this self-confessed "congenital optimist" (p. 102). As long as we pay close attention to the story, he asserts, and learn from the scientists, then naturally we will do the right thing—without recourse to religion. "The accidents of history are the source of meaning," he assures us, and "the concept of meaning is the worldview of science" (p. 12).

When Stephen Colbert challenged the philosophical reach of the big history story by saying that the facts it lays out are "the events of life, not the *meaning* of life," David Christian responded in the same way that Wilson does. "Meaning is in the map," he explained. "If you have a map it tells you where you are, and if you know where you are, you know where you can go." [1]

"*If* you know what the key says in the corner," Colbert replied.

Some would suggest, as Colbert went on to do, somewhat disingenuously I think, that the key to interpreting the map is to be found in the Bible or, by extension, other religious texts. A more modern response might be that it is found in philosophy or art or psychology or indeed in history itself. Regardless of Colbert's true personal beliefs, he framed the problem of meaning perfectly: Meaning as a concept only has validity in a metaphysical sense.[2] From this perspective, the meaning of human existence cannot be discovered using modern science.

If, as Wilson maintains, we are the product of "overlapping networks of physical cause and effect" (p. 13), by definition our existence is "meaning"-less. As Ian Hesketh puts it, "like any myth, big history's deep meanings are not inherently derived from empirical observations but from its anthropomorphic projections of an idealized cosmic world."[3] Harvard historian David Armitage is equally succinct, "Big history, in all its guises, has been inhospitable to the questions of meaning and intention so central to intellectual history."[4]

Then why would anyone go to all this trouble to reformulate a sweeping inquiry into the meaning of human existence? For two reasons, first, because not doing so cedes the field to the religiously-oriented, and second, because scientists and the scientifically-oriented *should* be addressing the moral concerns of our day—and big history in theory provides an excellent opportunity to address big moral and philosophical questions. In order to do so, however, the partnership between the natural sciences, the social sciences, and the humanities has to be an equal one.

On some levels Wilson senses this. Following the same line of reasoning that he elaborated in *Consilience: The Unity of Knowledge* (1998), he argues that the best way to facilitate the moral choices that he deem important is, in addition to accepting the truths revealed by science, to bridge the gap between the two cultures. Without question I believe this is correct, and it puts this book (along with Wilson's other work) firmly in the tradition of what he calls the "evolutionary epic," a concept he first developed in *On Human Nature* (1978). Along with similar studies such as Jacques Monod's *Chance and Necessity* (1971), Steven Weinberg's *The First Three Minutes* (1979), Paul Davies' *God and the New Physics* (1983), Ilya Prigogine and Isabelle Strenger's *Order out of Chaos* (1984), Lynn Margulis and Dorion Sagan's *Microcosmos* (1986) and Eric Chaison's *Cosmic Evolution* (2001), the evolutionary epic is a genre that entails, first, the posing of a philosophical problem, as in the book under review, and typically, the need to unify the sciences and the humanities; second, a long tour through the exciting scientific discoveries the author has made, in this work, specifically, multilevel selection;[5] and, finally, a philosophical conclusion that calls for a new morality, here, that we no longer need religion as a source of meaning or explanation.[6] This book is the very definition of an evolutionary epic. It has all the elements in place—including the conflict between its stated methods (scientific/objective) and its conclusions (anthropocentric/moral).

The sticking point is that, while the notion of consilience as the way forward is brought home throughout, it feels more like an arranged marriage than an equal partnership. There is something condescending and patriarchal in the way Wilson offers science as guide to, and protector of, the humanities. "Would the humanities care to colonize the sciences? Maybe use a little help doing that? How about replacing science fiction, the imagining of fantasy by a single mind, with new worlds of far greater diversity based on real science from many minds? Might poets and visual artists consider searching in the real world outside the range of ordinary dreams for unexplored dimensions, depth, and meaning?" (p. 12).

The tone is reminiscent of a recent essay by another Harvard scientist, astrophysicist Chaisson, who imagines a few intrepid historians, some twenty years ago, discovering that "much good and valid history extends far back in time, well prior to the ancient civilizations . . . even beyond the onset of hominins . . . It was as though, trekking up a mountain whose summit holds true knowledge, the big historians began realizing there's much more to history than we had been led to believe. . . . Yet hardly a decade ago, those same big historians, much enthused by their new story-telling agenda, discovered a different breed of scholars on the other side of the mountain."[7] In Chaisson's story, these hero-scholars are astronomers; in Wilson's, they are biologists. In both versions they are most emphatically leading the way.

It could be worse. At least the big historians demonstrate some internal fortitude and climb the mountain. Chaisson leaves the shilly-shallying philosophers "wondering wearily from mountainous ledges how the latest findings might impact their thoughts and beliefs that require no tests." For Wilson's part, he finds that "the history of philosophy when boiled down consists mostly of failed models of the brain" (pp. 160-161).

And here I think is the crux of the matter: the only definition of meaning that these scientists are willing to accept is one that begs the question. Then science becomes the super-hero, science as savior, but this wishful viewpoint is philosophically uninformed. Wilson presents science as pure and testable and free from ideology, based only on the facts, and then wants it to do things that are well beyond its imperative. Consequently, he holds a decidedly romantic notion of what a grown-up relationship with the humanities might be like. "Exalted we are, risen to be the mind of the biosphere without a doubt, our spirits uniquely capable of awe and ever more breathtaking leaps of imagination" (p. 25).

The reality is that the humanities—along with the social sciences, which Wilson bypasses altogether—have far more to contribute to our understanding of the meaning of existence than is here being supposed, first and foremost by examining the philosophy, history and psychology of science itself. For all his conciliatory rhetoric, it is clear that Wilson believes science to be the dominant partner and wants a relationship with the humanities only if it is going to be on science's terms; certainly not if it means taking seriously anything the humanities has to say vis-à-vis a philosophical critique of science, the history of science, or the implications of presenting this history in a narrative form. A real rapprochement will require scientists to admit that they do not actually have all the answers and that just because they are experts in entomology or astrophysics does not mean that they can be our guides to everything else as well.

Realigned somewhat from the meanings he found in nature in the 1970s (the potential for genetic engineering, human rights, diversity in the gene pool), now, in this book, Wilson finds the most meaningful issues to be *not* fooling around with genetic engineering, biodiversity (again), and two new items, environmentalism, and what he now sees as "the greatest goal of all time, the unity of the human race" (p. 174), by which he means bringing an end to all forms of "tribalism," foremost among them sectarian conflict. Naturally, his main point is that the "prerequisite for attaining the goal [of human unity] is an accurate self-understanding. So, what is the meaning of human existence? I've suggested that it is the epic of the species, begun in biological evolution and prehistory, passed into recorded history, and urgently now, day by day, faster and faster into the indefinite future, it is also what we will choose to become" (p. 174). And there you have it.

The Meaning of Human Existence is a stimulating, anthropocentric tour through the thinking of one of the world's foremost entomologists. Wilson is an excellent writer and for those already familiar with his work this book contains some diverting anecdotes and observations unpublished elsewhere. "What can we learn of moral value from the ants?" he quips (p. 95). "Here again I will answer definitively. Nothing."

Wilson's tough on religion, more so than in his other books, describing religions as "impediments to the grasp of reality needed to solve most social problems in the world" (p. 150). And his tone of moral outrage has risen several degrees. We are bad at government; businessmen and political leaders believe in all sorts of crazy, superstitious stuff; we seem "unable to stabilize either economic policies or the means of governance higher than the level of a village" (pp. 176-177); the population is growing too fast (because it is taboo to talk about enforcing birth limits). As a result, we have made a mess of the environment. Worst of all, some people still do not believe in evolution.

All this because "*Homo sapiens* is an innately dysfunctional species" (p. 176). Wilson blames arts and humanities scholars for not spending enough time wondering about why human nature is the way it is and what that means. To my surprise, he doesn't spare his colleagues either: "Scientists who might contribute to a more realistic worldview are especially disappointing. Largely yeomen, they are intellectual dwarves content to stay within the narrow specialties for which they were trained and are paid" (p. 178). All in all, Wilson's journey through his own mind is a rather entertaining jaunt. Being a curmudgeon myself, I enjoyed going along for the ride.

David Blanks
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(Endnotes)

1 The Colbert Report, Season 10, Episode 22, November 12, 2013, http://www.cc.com/video-clips/91wur1/the-colbert-report-david-christian.

2 This is what philosophers refer to as the analytic-synthetic distinction. See for example Stephen Anderson, "The Meaning of 'Meaning,'" *Philosophy Now* Issue 88, January/February 2012, https://philosophynow.org/issues/88/The_Meaning_of_Meaning.

3 "The Story of Big History," *History of the Present: A Journal of Critical History*, Vol. 4, No. 2 (Fall 2014): 196.

4 "What's the Big Idea? Intellectual History and the *Longue Durée*," *History of European Ideas* 38:4 (December 2012): 494.

5 In biology multilevel selection (as opposed to inclusive fitness) includes a consideration of the effect of individual *competition* within the group as well as *cooperation* among members of a group for the purpose of competing with opposing groups. It explains, among other things, altruism, and, most importantly for the present purposes, our propensity for religious behavior. Wilson goes over this is detail in an appendix (pp. 189-202).

6 On the evolutionary epic as a genre, see Martin Eger, "Hermeneutics and the New Epic of Science" in *The Literature of Science: Perspectives on Popular Scientific Writing*, ed. Murdo William McRae (Athens: The University of Georgia Press, 1993), pp. 186-209. On big history as evolutionary epic, see Ian Hesketh, "The Story of Big History" and "The Recurrence of the Evolutionary Epic," *Journal of the Philosophy of History* 9 (2015): 196-219. My particular thanks to Dr. Hesketh for leading me to the seminal discussion of the evolutionary epic found in Eger.

7 "Big History's Risk and Challenge," *Expositions* 8:1 (2014): 85-95, https://www.cfa.harvard.edu/~ejchaisson/reprints/Expositions_BH.pdf.

I Contain Multitudes: The Microbes Within Us and a Grander View of Life. ED YONG. New York: HarperCollins, 2016. 355pp. $27.99 (hardcover).

Not every generation gets to witness the transformation of heresy into dogma. We didn't get to read the Copernican revolution in the literature as it happened. Nor the Darwinian one. But we are in the midst of one right now.

So fresh and on-the-cusp-of is this revolution, that it has no eponymous name associated with it. Candidates for that honor might include Anton de Bary who coined the term symbiosis; Ivan Wallin who recognized that mitochondria are symbiotic bacteria living in the cellular cytoplasm; Konstantin Mereschkowski who coined the term symbiogenesis; or Lynn Margulis who advanced and substantiated a theory of a symbiotic Earth.

There will, however, be no disputing the name of a science writer who described this revolution in a rigorous and delightfully readable book. Ed Yong is a science writer for *The Atlantic* and *National Geographic* hosts his blog, Not Exactly Rocket Science. He lives in London and Washington, D.C.

When he gives a talk about his new book, Yong walks from one side of the stage to other, pointing out milestones in the epoch of life on Earth much like a big historian. He starts with the formation of the Earth at one end of the stage, points out the emergence of prokaryotic life about a quarter of the way across, the emergence of eukaryotic life before halfway mark, the emergence of multicellular life an inch before the end of the stage, and the emergence of humans, of course, at the *actual edge* of the stage. Seeing this timeline on stage, it's easy to think of the prokaryote as distant relatives, separated from us by millions years. But the central thesis of Yong's book is that we are not distant nor separate from those ancient life forms at all. They are, in fact, us.

Yong synthesized 10 years of articles about the microbes within us so that readers can experience a grander view of life. Debunked is the notion that any eukaryotic organism is a single individual. He describes an early Earth teeming with prokaryotes. Every inch of land and sea, ice and atmosphere is covered or saturated with bacteria and archaea. "For roughly the first 2.5 billion years, bacteria and archaea charted largely separate evolutionary courses. Then, on one fateful occasion, a bacterium merged with an archaeon," prototyping the first eukaryote (p.9). Swept into the dustbin is also the notion that inherited genes alone are responsible for the great diversity on Earth. At every level—bodies, organs, cells, even nuclei—and in every function—metabolism, reproduction, development, homeostasis, and most surprisingly speciation—prokaryotic life is enriching the genetic potential of all eukaryotic life.

Wait, what? What's wrong with rugged individualism? "Bacteria," Yong answers, "are infinitely more versatile than we are. They are expert pharmacologists…[and they] reproduce rapidly and swap genes readily. In the great evolutionary race, they sprint, while we crawl" (p. 207). Evolution does its slow work through heredity, but it can move at a blinding pace through symbiosis since complex plants and animal bodies "are hubs of genetic innovation, because they allow DNA to flow more freely between the huddles masses of microbiome" (ibid.).

One of the most compelling examples of this symbiotic view of life is the Hawaiian Bob-tail Squid and its relationship with bioluminescent bacteria called *Vibrio fisheri*. Yong takes us on a field trip to the lab where tanks of these squid at all ages are being studied. Upon seeing a thumb-sized squid up close, changing before his eyes from white to "an autumnal scene painted by Seurat" Yong confesses, "I'm rather taken. The squid oozes personality" (p.49).

The squid hides in the sand by day but it feeds at night. It swims on the surface of shallow water and is preyed upon from below by fish good at detecting shadows. So it's a good thing the squid is equipped with a specialized light organ that acts like an invisibility cloak. This ability to hide is a superpower masterminded by a symbiosis. The researchers attach a florescent marker to a group of bioluminescent V. fisheri microbes and watch as they make the squid a new invisibility cloak every day.

During the day, the surface of the light organ is covered in mucus and beating hairs called cilia. The hairs create a current that draws in particles of bacterial size. Microbes amass in the mucus, V. fisheri among them. When at least five of V. fisheri, enough to make a quorum, detect the presence of a squid, they start spewing out a cocktail which repels or kills any other microbe and attracts even more V. fisheri. The column of pure V. fisheri marches into the light organ. Once inside, the microbes release enzymes that remodel the light organ to make room for themselves and close the door behind them. When night falls, sensors on the top of the squid detect the precise amount of moonlight. That information gets communicated to the light organ community so that when they simultaneously decide to turn on their light, the light shining down from the squid matches the light shining down on the water (p. 51).

This single instance of symbiosis reveals a stunning amount of agency for a group of blind, gutless, and brainless prokaryotes—they sense physical parameters, talk to each other, make group decisions, synthesize innovative enzymatic actions, encourage tissue growth, and modify host social behavior. Even harder to believe is that the microbiome is not a constant entity. The bacteria in the squid are pumped out of the light organ every morning and re-recruited every afternoon.

This is an astonishingly complex procedure, one that certainly caused this reader's jaw to drop. Like the collective shock and awe emitted from the globe when the image of Earth from the moon was beamed from space in 1969, we are likely to be changed after reading Yong's book. Although we have no crisp image to stare at, Yong's compilation of vignette after vignette paints a picture in our mind's eye that life on Earth is a collection of nested ecosystems, from the climate to the nucleus of a gut cell in a fruit fly.

This revelation has implications for managing the well-being of the ecosystems that surround us and live within us. It might move us away from waging war with disease, infection, allergy, and autoimmunity and toward tending the invisible gardens of microbes instead. It might encourage us to forgo biocides—pesticides, herbicides, fungicides—and focus on learning how to use diversity to grow the ecosystem services we crave. We do have to be careful, Yong warns. "Symbiotic microbes are still their own entities, with their own interests to further and their own evolutionary battles to wage. They can be our partners, but they are not our friends. Even in the most harmonious of symbioses, there is always room for conflict, selfishness, and betrayal" (p.76).

At the very least, reading this book would make big historians recognize that we need to update the grand narrative with a fuller discussion of prokaryotic symbiosis. Without symbiotic relations; there would be no eukaryotes, no multicellularity, no adaptive immune system. There would be much slower adaptations to new habitats and food sources, slower co-evolution between plants and animals, and perhaps considerably less speciation.

At its core, the book adds another dimension to our understanding of increasing complexity. Recapitulating the narrative of big history, Yong writes "cities are hubs of innovation because they concentrate people in the same place, allowing ideas and information to flow more freely." Likewise, our bodies concentrate bacteria. "Close your eyes" he continues, "and picture skeins of genes threading their way around your body, passed from one microbe to another. We are bustling marketplaces, where bacterial traders exchange their genetic wares" (p.196).

Perhaps understanding the role of prokaryotic symbiosis in the life sector of the big history narrative will give us a useful metaphor for understanding the cosmic, Earth and humanity sectors of Big History. Are molecules the first example of symbiosis? Is the gravitational asteroid-sweeping that Jupiter provides for Earth reciprocated? What is the influence of Earth's gravity on the potential for life on Europa? What is the best way to promote human dignity across the globe—keeping cultures distinct and separated, or connected and homogenized? The metaphor is a certainly a generative one.

The application of this new idea is generative as well. The final chapter is an uplifting one. Yong describes just of a smattering of the research and development that is exploding in the literature on health, agriculture, aquaculture, pest management, personalized medicine, and ecosystem management on land and sea. It is a great gift to humanity when the scientific endeavor generates a grander view of the grand narrative. *I Contain Multitudes* provides us with a panoramic look at this grandeur.

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The Gene: An Intimate History. By SIDDHARTHA MUKHERJEE. New York: Scribner, 2017. 592 pp. $32.00 (hardback).

Dr. Siddhartha Mukherjee, author of the highly regarded and Pulitzer Prize winning *The Emperor of All Maladies*, has undertaken what he terms as an "intimate history" of the gene. Mukherjee's medical credentials are impressive, yet they are also atypical for research and writing on the history of science. *The Gene* is impeccably written and expands our understanding of a well-known history through his unique viewpoint. In fact, Mukherjee's work is reminiscent of another Pulitzer Prize winner, Jared Diamond. Originally a physiologist, Diamond, is best known for applying his scientific viewpoint to the Spanish Conquest in his 1997 Pulitzer Prize winning *Gun's Germs, and Steel*.

Mikherjee gives two reasons behind writing the book. First and foremost is his family's medical history. The opening chapter of the book, and consistent interludes throughout, share the stories of three family members plagued with mental illness: Rajesh, Jagu, and Moni. Moni, who at the time of publication resides in a mental institution in Calcutta, was particularly influential to the author's mindset on heredity. In a stirring paragraph, the author remarks that *The Gene* is "a very personal sort—an intimate history. The weight of heredity is not an abstraction for me" (p. 14). The second root behind *The Gene* is Mukherjee's medical work as a cancer biologist. On a daily basis, he was interfacing with genetics, as he describes cancer as the "ultimate perversion of genetics—a genome that becomes pathologically obsessed with replicating itself" (p. 9).

The primary claim made in the book is one of significance, specifically the importance of the gene within the history of science. Mukherjee argues that the gene is a "powerful and dangerous idea…the fundamental unit of heredity, and the basic unit of all biological information" (pg. 9). Mukherjee goes on to explain that the gene parallels the atom and the byte. Just as the atom is the basic unit of all matter and the byte is the basis for all digitized information, the gene the basis of all biology.

In order to prove his point, Mukherjee opted to craft *The Gene* as a (mostly) chronological history, broken up into six sections. In the first section, Mukherjee tours all early scientific research relevant to heredity and genetics. He begins with Gregor Mendel's pea garden, covers Charles Darwin's *On the Origin of Species,* and ends with the rise of eugenics as told from the stories of Francis Galton and *Buck v. Bell*. In this section Mukherjee also briefly tours the Ancient Greek minds of Pythagoras, Aristotle, and Plato within the context of how they influenced Mendel and Darwin.

In the second section, entitled, "In the Sum of the Parts, There Are Only the Parts," Mukherjee continues following the history of human understanding of the gene. Of note here is the initial realization that "the gene was born 'outside' biology" (pg. 95). That is to say that the discovery was not made by biologists nor was it immediately applied by the renown biologists of the era. Of course, the irony is that the gene held the answers to many of the major questions that the biological field was addressing at the time; it just took a while for biologists to realize that. This section includes a discussion of Thomas Morgan's discovery that genes moved in "packs," the Third Reich's "applied biology," and a number of major post-World War II breakthroughs in biology (p. 120).

Parts three and four denote a slight change in content; whereas Mukherjee continues to focus on the development of human understanding, but he does so through the detailed analysis of two transformative technologies from the 1970s: gene sequencing and gene cloning. By emphasizing these specific technologies, the book takes a more technical tum exploring modern medical research and the techniques used to map and identify genes linked to disease. The highlight of these sections is found in part four with analysis on the launch and findings of the Human Genome Project. The last chapter of these two sections, "The Book of Man," simply lists bullet points highlighting facts from the complete human genome mapping, such as "It has 3,088,286,401 letters of DNA (give or take a few)" (p. 322).

Parts five and six continue the narrative of increased human understanding over time; however, they do so almost as applied science, analyzing the gene within a variety of particularly relevant social issues. Section five, "Through the Looking Glass," discusses different topics researched over the past twenty years as a means of linking the gene with personal and cultural identities and the concept of societal "normalcy." This includes topics such as racial identity, sexual determination, and Dean Hamer's search for a genetic link with sexual orientation. Part six looks toward the future, including potential medical breakthroughs and ethical dilemmas. Most notable here is our current ability to manipulate human genetics, which invites the cliché 'opening Pandora's Box' metaphor. Luckily, the author supplied a better summation with his poignant contention that "our capacity to understand and manipulate human genomes alters our conception of what it means to be 'human'" (p. 12).

Taken in its entirety, *The Gene* synthesizes an impressive breath of information from multiple fields. Much of the book's content is typically recorded by historians who study the history of science; however, Mukherjee additionally analyzes recent genetics and biological research (as well as legal history, politics, and social mores) to compile a narrative that shows how human understanding of the gene has changed over time. In order to craft this history, the author largely leans on previously published works for sections one and two. In parts two and three, however this methodology appears to shift as Mukherjee crafts what is arguably the first complete draft on the history of genetics from 1970 to the early 2000s. Parts five and six are less cohesive as a narrative history, but this is an expected problem when one's historical narrative arrives at the present and speculates into the future. *The Gene* represents an incredible amount of research, and his work is to be commended.

As for its application to the field of big history, the book notably does not employ familiar concepts or tools such as complexity, scale, or emergent properties to tell his story. Perhaps the crux of the issue is that *The Gene: An Intimate History* is really not a history of the gene as the title seems to imply and does not utilize different scales of time, which seems like a natural fit, for analysis. Instead, Mukherjee's remarkable book is a better labeled as a history of science, crafted by studying scientists and using their published papers, the historical record, and signs of their impact on society as evidence. In addition, *The Gene* functions more as a textbook designed for a popular audience rather than as a monograph with extensive archival or data based research. Despite its academic approach and formatting, its appeal, with the notable exception of parts three and four, is likely to be less to big historians and more for curious readers.

The big history of the gene remains unwritten, but this is not to say that *The Gene* does not hold value for big historians. Mukherjee asks thought-provoking questions, adds perspective on multiple well-known figures in the big history narrative, and traces the interesting concept of human understanding of genetics into what was previously a largely unwritten history. *The Gene: An Intimate History* certainly has a place on every big historian's bookshelf.

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Cultural Materialism: The Struggle for a Science of Culture. By Marvin Harris. Updated ed. Walnut Creek, Lanham, New York and Oxford: Alta Mira Press, 2001. 381 pp.

To unite natural and human history big historians must try to describe carefully how material conditions and human cultural processes relate to each other. To do this, a plausible scientific theory of human culture is needed. Marvin Harris, an anthropologist, tried, over his lifetime, to formulate such a theory.

Marvin Harris (1927-2001) was born in Brooklyn, NY, to impoverished parents of Russian-Jewish ancestry. He wrote his doctoral dissertation at Columbia University on a village study in Brazil and joined the faculty. In 1957, on fieldwork in Mozambique, he changed his focus from ideological to behavioral aspects of human behavior. He taught at the University of Florida from 1981-2000 and wrote two textbooks, each in seven editions, plus 17 other books, for both academic and general audiences.

Harris was determined to articulate a scientific theory of sociocultural development. By 1968 he stated his theory and named it 'cultural materialism' in his book, *The Rise of Anthropological Theory*, known to two generations of anthropology graduate students as the RAT. At that time Harris' theory was not the dominant one among anthropologists; he spent years arguing for it, specifically in the first edition of *Cultural Materialism: The Struggle for a Science of Culture* (1979). Near the end of his life he updated both the RAT and *Cultural Materialism*. By that time his colleague, Maxine L. Margolis, could state in her introduction to the RAT that cultural materialism was the "major theoretical paradigm and research strategy in anthropology," despite the surge in anti-scientific post-modernism in other fields of the humanities.

In his preface to *Cultural Materialism* Harris wrote that cultural materialism "is based on the simple premise that human life is a response to the practical problems of earthly existence." His theory of cultural materialism prioritizes material conditions as more likely than ideas to be causal in human societies. Harris lays this out in a scheme of infrastructure, structure, and superstructure (55-59). Under infrastructure he puts <u>modes of production</u> (technology of subsistence, techno-environmental relationships, ecosystems, and work patterns) and <u>modes of reproduction</u> (demography, mating patterns, fertility, etc.). Under structure he puts <u>domestic economy</u> (family structure, domestic division of labor, socialization and education, sex roles, etc.) and <u>political economy</u> (political organization, taxation, division of labor, class, hierarchy, control, war, etc.). Under behavioral superstructure he puts art, music, dance, literature, rituals, sports, games, and science.

The above categories are all behavioral categories used by anthropologists in describing and understanding cultural communities. Like many anthropologists, Harris calls these categories *etic.* But there are also categories and concepts applied by native informers to their lives and their world, called *emic* categories. They include ethno-botany and ethno-zoology, magic, religion and taboos. (The anthropological linguist, Kenneth Pike, introduced both terms in his book, *Language in Relation to a Unified Theory of the Structure of Human Behavior*, 1967.)

Harris asserts the principle of infrastructure determinism, namely, that "the etic behavioral modes of production and reproduction probabilistically determine the etic behavioral domestic and political economy, which in turn probabilistically determine the behavioral and mental emic superstructures" (55-56). He acknowledges that the emic superstructure has influence, but he wants to explore fully the influence of the etic infrastructure and structure before considering the influence of the emic superstructure (56). He finds that the interactive exchanges that occur among the superstructure, the structure, and the infrastructure are important in sustaining, accelerating, or deflecting the direction and pace of transformational processes initiated within the infrastructure (160).

Harris describes the infrastructure as "the principal interface between culture and nature, the boundary across which the ecological, chemical and physical restraints to which human action is subject interact with the principal sociocultural practices aimed at overcoming or modifying those restraints" (57).

In a word, Harris rejects the notion that ideas change the world. He claims that ideas gain traction only to the extent that they fit the material conditions in which people find themselves. Mental and spiritual aspects of culture are significant, but they are not able to explain why different human populations have different sets of values, beliefs, and aesthetic standards. For Harris, the causes of human behavior patterns lie ultimately in the material conditions of the infrastructure.

Harris used this example to make his theory concrete: " . . .during the late 1960s many young people believed industrial capitalism could be destroyed by a 'cultural revolution.' New modes of singing, praying, dressing, and thinking were introduced in the name of a 'counterculture.' These innovations predictably had absolutely no effect on the structure and infrastructure of U.S. capitalism, and even their survival and propagation within the superstructure now seems doubtful except insofar as they enhance the profitability of corporations that sell records and clothes" (72).

Do big historians generally prioritize what Harris calls the infrastructure---the environment, technology, demography, food, basic survival---in describing and explaining human culture and history? I think that we generally do, with some important additions. One addition is David Christian's concept of collective learning as distinctive and crucial to human expansion. Perhaps Harris would have included collective learning in his technology of subsistence if he had known the term. But collective learning also seems part of the superstructure of literature, science and religion. Harris recognized learning as a major factor in making cultural evolution different from biological evolution in his textbook, *Culture, People and Nature* (2nd ed. 1975), but he didn't discuss this in *Cultural Materialism* (2001) or in the 7th edition of his textbook (1997).

Other additions by big historians include our emphasis on energy flows and optimal (Goldilocks) conditions. Both of these are material infrastructure conditions, but Harris does not mention them.

Harris wrote *Cultural Materialism* for an academic audience. In it he uses technical and theoretic language and devotes many chapters to answering his critics, such as structuralists (a form of idealism, he says), post-modernists, dialectical materialists, socio-biological reductionists, and eclecticists. Parts of this book could be useful in advanced and graduate big history courses for laying out possible positions and for provoking discussion of the issues. Learning about his theory of infrastructure determinism may help big historians understand the underlying assumptions that we may be making.

Yet Harris's ideas also seem dated. We need an analysis of current positions to move us toward a scientific theory of culture. The synthesis of science and the humanities seems incomplete until we have formulated a working theory. Clearly, the tangible and cognitive systems are intertwined and interactive. But in what ways? Which predominates? Which is causal? Are they chaotic, unpredictable, and inconsistent? Discussing Harris' theory of cultural development can help us move toward formulating an improved theoretical paradigm.

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A Most Improbable Journey: A Big History of Our Planet and Ourselves.
WALTER ALVAREZ. New York, NY: W.W. Norton and Company, 2016.
256 pp. $26.95 (hardcover).

A number of books are now available that give the reader a grand narrative of our universe from the Big Bang to our own immediate present, so what can yet another "big history" book contribute to that field? For Walter Alvarez, the geologist who identified the asteroid impact responsible for the demise of the dinosaurs, the answer is, naturally enough, in telling big history with planet Earth as the star of the show.

For Alvarez, imparting an abundance of information is less important than sharing an abundance of enthusiasm. Geology is a slow process, and a narrative that went into excessive detail could unintentionally convince the general reader that nothing important is happening. For example, Robert M. Hazen's worthy book, *The Story of Earth* (2012), tells our planet's history in rich detail, but presumes a reader already willing to engage in such detail. Alvarez makes no such presumption; if anything, he presumes the opposite. Elsewhere Alvarez has written that geology can seem "arcane" and "foreign" to most people, seeming "of little use in everyday life." This is where his skill and experience as an educator are apparent; he knows that it is enough at the beginning simply to generate excitement and interest.

Alvarez begins with a quick account of cosmic history, from the Big Bang to the birth of planet Earth, but in a chatty and almost cursory fashion. He is well aware that this story has already been told in detail by authors specializing in astrophysics, such as Eric Chaisson and Steven Weinberg, and wisely does not attempt to repeat that kind of narrative. He gently nudges Edwin Hubble aside and instead gives attention to one of the less celebrated players, Milton Humason, "a boy who dropped out of school at age 14 to drive a team of mules and had no further formal education" (p. 24) Humason's biography may be a digression, but it is a digression with a purpose: Alvarez wants to keep us entertained. He understands that the expansion of the universe may seem remote and abstract to many readers, but the human interest in the story of a high school dropout becoming Hubble's scientific partner has broad appeal. By sharing Humason's personal journey from mule skinner to janitor to scientist, Alvarez gently draws readers of varied backgrounds into his cosmic story. By the time Alvarez arrives at the birth of planet Earth, the reader may not have all the facts about the early universe, but is certainly well prepared to appreciate the next chapter in the tale.

That next chapter, "Gifts From the Earth," focuses on the processes that make material resources useful to humans. The unique strength of Alvarez's book is that it places geology in the foreground of the story, all the while making it clear that the dynamic processes of our planet have an ongoing impact on the human story. This is a worthy accomplishment, as many people have difficulty appreciating the story of non-living rock, and are inclined to view planet formation as simply setting the stage for the appearance of life. Not so in Alvarez's narrative, which consistently keeps geological history relevant to the modern world. Preferring one good example to a sprawling catalog, Alvarez devotes most of this chapter to telling the story of the element silicon, from sandy beaches, to the first stone tools, to stained glass for cathedral windows, and to the computer chips that enable almost every aspect of modern human life.

This chapter, and the three that follow, make up the core of the book, focusing in turn on Earth's major geographic features: continents and oceans; mountain ranges; and ancient rivers. Alvarez moves in close on exciting details such as the earthquake that destroyed Lisbon in 1755, then contextualizes those details in the larger perspective of plate tectonics. He introduces familiar names and events such as the voyages of Columbus, giving the reader a reference point, and then makes the familiar fresh and new by telling the tale from a geologist's point of view.

This talent for introducing a geological interpretation truly shines in the seventh chapter, "Your Personal Record of Life History." Instead of referring to the strata of rocks, Alvarez uses the physical evidence of our own human bodies to recount Earth history. While much of the book follows a loose chronology, sliding backwards and forwards in time as suits the topic of the moment, this chapter follows a linear path through time, identifying in proper order the geological periods in which various parts of our anatomy evolved. More than anywhere else in this book, he makes use of the jargon of his profession ("Hadean," "Archean," "Proterozoic"), but instead of being obtuse and intimidating, the terms become personal and meaningful.

Although the book is broadly organized into four chronological regimes – Cosmos, Earth, Life, & Humanity – Alvarez makes it clear he is not worried about following a strict timeline. His introduction plainly states, "Although there is a continuity from chapter to chapter, feel free to read them in any order that interests you." In that spirit of fueling the reader's curiosity, Alvarez's concluding chapter is not really a conclusion at all, but rather a reminder to reflect on the grand story of our planet, and experience some awe and wonder. The chapter title is a question, "What Was the Chance of All This Happening?", followed by another question in the final sub-section heading, "How Improbable Are We?". Alvarez gives some numbers and figures on probability, but again without expecting the reader to engage in technical details. He considers it a success to be able to raise the questions, to invite the reader's curiosity.

The book is short and the pacing is brisk. Alvarez provides just enough detail with each example to create excitement, and then moves quickly to something new, well before the reader has a chance to lose interest. The loose structure and lively pacing are comparable to the very best television documentaries on the natural world, stimulating interest and leaving the audience ready for more. This is not a "dumbing-down" of the material, however. Quite the contrary, Alvarez loves the facts of the natural world and imparts them with accuracy. But he knows that this is not a textbook, and portions out the hard data accordingly. His introduction declares that he seeks to leave the reader "with a delight in a whole series of fascinating stories" and "new questions," and in that he certainly succeeds.

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Vincent van Gogh
(1853-1890)
Starry Night over the Rhône
1888

Oil on canvas
H. 72.5; W. 92 cm
Paris, Musée d'Orsay
Donation by Mr and Mrs Robert Khan-Sriber
with life interest reserved,
in memory of
Mr and Mrs Fernad Moch, 1975

https://commons.wikimedia.org/wiki/File:Starry_Night_Over_the_Rhone.jpg

Note on Cover Painting

As David Christian has observed, Vincent van Gogh's painting, "La nuit étoilée" ("Starry Night over the Rhône"), beautifully integrates many of big history's themes.