"The keen longing for unified, all-embracing knowledge": Big History, Cosmic Evolution, and New Research Agendas[1]

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Abstract: This article offers an interpretation of recent attempts at the unification of knowledge. It argues that today's scholarly world is aberrant. It is splintered into distinct scholarly disciplines to such an extent that universities and research institutes have lost what Erwin Schrödinger called "the keen longing for unified, all-embracing knowledge." In contrast, most earlier human societies have valued the search for an underlying unity to human knowledge, a unity that was both conceptual and narrative, and often took the form of "origin stories". Unifying knowledge on the basis of modern science was also one of the central projects for the Enlightenment and for many nineteenth century thinkers. But at the beginning of the twentieth century, in every country in the world, knowledge was broken up into disciplines, to such an extent that most educators and researchers lost sight of the ancient hope of seeking an underlying unity to all knowledge. The essay describes the fragmentation of knowledge in the twentieth century and discusses reasons for that sea-change in the modern knowledge system. But it also argues that the period of extreme disciplinarity, in which the disciplines blocked the free flow of ideas between disciplines, may prove short-lived. The emerging transdisciplinary fields of "Big History" or "Cosmic Evolution" may herald a general scholarly return to a more balanced relationship between detailed research and the quest for large, unifying frameworks.[2] This paper ends by speculating about how a return to the project of unifying knowledge may transform education, research agendas, and the institutions within which they take place.[3]

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Charles Darwin:
From my early youth I have had the strongest desire to understand or explain whatever I observed — that is, to group all facts under some general laws. [*Autobiography*]

Erwin Schrödinger:
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.[4]
[*What is Life?*]

Introduction:

The epigraphs capture the central claim of this essay: that good education and research depend on a balance between detail and generality, between sharply-focused research, and the unifying intellectual frameworks that help us make sense of, and find meaning in, detailed research.

When Darwin wrote, the need for such a balance was well understood, and his own career offers a spectacular example of the extraordinary synergies that can be generated by connecting detailed research to deep, unifying ideas. Schrödinger wrote just after World War II, when scholars in most fields had

abandoned the search for unifying ideas. His comment is a plea to re-establish a lost balance.

Today, we still live in an unbalanced scholarly world in which research normally means sharply focussed enquiry within the boundaries of particular disciplines. In such a world, research that tries to link ideas across many disciplines looks extreme, and (a bit like extreme sports) it can seem over-ambitious and unrealistic. But such projects seem extreme today only because of the emergence, early in the twentieth century, of structures that partitioned teaching and research between distinct scholarly disciplines. That change was so swift and so decisive that today few scholars show any interest in the unifying projects that were once the complement to all detailed research.

Coherent worlds of Knowledge before the twentieth century

So complete was the disappearance of the ancient quest for intellectual unity and harmony, that it can come as a shock to realize how important such unifying projects were for much of human intellectual history, and how recently they lost their centrality in most fields of scholarship.

Almost all human societies have constructed origin stories or creation myths: large, inter-linked collections of stories that summarize a community's best understanding of how things came to be as they are, by harmonizing many different types of knowledge.[5] Whether in small-scale societies with ancient oral traditions built up over many generations, or in societies with writing and institutionalized religious traditions, origin stories were powerful because they summed over a society's core understandings of reality. Origin stories shaped identities because they told you who you were, what you were part of, what roles you could play, and what roles you should play, so they usually structured how young people were educated.[6] As Marie-Louise von Franz argues, Creation Myths: "… refer to the most basic problems of human life, for they are concerned with the ultimate meaning, not only of our existence, but of the existence of the whole cosmos."[7] To take one random illustration, the thought world of Isaac Newton was framed from childhood to old age by the origin stories embedded within Christianity, and Newton's science flourished within these unifying stories. He thought of God as the "first cause", and once described the Universe as "the Sensorium of a Being incorporeal, living, and intelligent."[8]

It is important to avoid the common error of assuming that unifying projects must suppress diversity and dissidence. This was never true. Origin stories were always capacious enough to allow for disagreement. Isaac Newton, though a devout Christian, opposed the doctrine of the Trinity and was, technically (and discreetly) an "Arian", a denier of Christ's divinity.[9] Similar tensions existed within all origin stories, and all religious and philosophical traditions. Indeed, as with modern scientific paradigms, it was the sharing of fundamental ideas that gave salience and significance to differences in interpretation, and sometimes made them worth fighting over. Modern descriptions of all "grand narratives" or unifying projects as necessarily monolithic and unchanging are simplistic caricatures.[10]

As modern science emerged, it re-directed the quest for intellectual harmony and unity. The pioneers of modern science, and the major thinkers of the Enlightenment era, aspired to a new understanding of reality, and origin stories that would be based not on tradition, faith or authority, but on Reason and empirical research. "[W]e in effect propose a compleat system of the sciences," wrote David Hume, "built on a foundation almost entirely new, and the only one upon which they can stand with any security."[11] Science, they believed, would set new standards for reliable knowledge, and release humanity from naïve trust in faith or authority. "Enlightenment," wrote Immanuel Kant, "is man's release from his self-incurred tutelage [literally, Unmündigkeit, or "minority"]… [his]

inability to make use of his understanding without direction from another. … Sapere aude! 'Have courage to use your own reason!'- that is the motto of enlightenment."[12] Most Enlightenment thinkers were convinced that a better and more coherent understanding of reality would advance the progress of humanity as a whole.[13]

It is possible to identify two overlapping colours or qualities to the Enlightenment's unifying project, and it may be that the same two colours can be identified in all origin stories.[14] The first approach emphasises historical or narrative coherence, so it tends to take the form of stories or histories. It assembles diverse types of knowledge, like so many coloured tiles or pixels, into coherent accounts of how things came to be. Such narratives can be found at the heart of most religious traditions. The second approach can also yield large unifying narratives, but its primary emphasis is on conceptual unity, on the search for networks of ideas that are locked together tightly enough to provide a foundation for most of knowledge. Traditionally, this approach has shaped much theological, philosophical and mathematical thought, and today it can be found in unifying ideas such as General Relativity or Quantum Physics. The two approaches have always overlapped and reinforced each other. Thus, all the world religions contain large stories linked to logically rigorous foundational systems of ideas about how the Universe works.

The search for a science-based origin story flourished in Europe from the early eighteenth century. The search for conceptual unification drove the great intellectual systems of the nineteenth century, those of Hegel, Comte, Marx, Spenser and many others, though most of these systems also generated grand historical narratives. The emphasis on narrative unity shaped the natural histories of Buffon or the Universal histories of Voltaire, as well as nineteenth century universal histories, such as Alexander von Humboldt's multi-volume Kosmos, or Robert Chambers' Vestiges of the Natural History of Creation, which would have a profound influence on Charles Darwin.[15] The deep desire to keep in touch with the underlying unity of life and the universe also drove much of the Romantic reaction against what many saw as the arid scientism and the extreme focus on detail of some scientific thought.

The quest for intellectual unity still flourished in the late nineteenth century, in both its conceptual and narrative forms. While James Clerk Maxwell showed that electricity and magnetism were different expressions of the same underlying force, the historian, Leopold von Ranke (often thought of as the primary exemplar of small-scaled historical research) warned against "the danger of losing sight of the universal, of the type of knowledge everyone desires. For history is not simply an academic subject: the knowledge of the history of mankind should be a common property of humanity …."[16]

The Fragmented Knowledge World of the twentieth century

Early in the twentieth century, the unifying project vanished like a ghost at dawn. And it vanished so completely that, a century later, it is easy to forget how normal such projects once seemed. Two decades into the twentieth century, most scholarship and research was conducted within the well-policed borders of particular scholarly disciplines, and fewer and fewer scholars were willing or able to look for harmonizing concepts or stories that crossed multiple disciplines.[17] Those that tried, such as H.G. Wells, were widely regarded as dilettantes, and had little impact on the academy. Suddenly, except in areas such as Physics, where unifying paradigm ideas such as General Relativity flourished, interdisciplinary research and scholarship began to seem extravagant, wasteful and unnecessary: a quaint intellectual hangover from an era in which scholars had not yet grasped their impossibility.

For most of the twentieth century, scholars and researchers inhabited an intellectual world whose borders were as well patrolled as those of modern nation states. An influential 1972 OECD report on interdisciplinarity noted the exclusivity and competitiveness of these new intellectual statelets. Each discipline, it argued, consisted of: "A specific body of teachable knowledge with its own background of education, training, procedures, methods and content areas," and its own well-defined territories, interests, rituals and leaders, so that they often functioned like "autonomous fiefdoms".[18]

The idea of distinct scholarly disciplines is old, of course, as old as the first attempts to describe and certify specialist knowledge and skills. But in the narrower sense referred to here, "disciplines" emerged in the late nineteenth century, along with modern research universities.[19] German universities pioneered today's combination of research and teaching within well-defined discipline borders. But the model was soon copied elsewhere, and, in the early twentieth century it spread throughout the world.

> By the end of the nineteenth century a worldwide revolution in practice was beginning, …. The desire to emulate German universities led to the modern university in one country after another. Disciplines developed in association with licensing regulations or their de facto surrogates, and disciplinary organizations developed to define portions of academic turf. By 1910 the modern disciplines, and the modern research university, had been defined.[20]

In many ways, the turn towards extreme disciplinarity was a success. The disciplines provided containers for research agendas that might otherwise have grown unmanageably. Within those safe spaces, research flourished throughout the twentieth century.

But the achievements came at a cost. Discipline-based research flourished, a bit like potted plants, because it was confined. Where thought threatened to sprawl unmanageably, the disciplines pruned over-reaching branches and root systems, creating the intellectual equivalent of a bonsai garden. As Fred Spier puts it: "In the real world, everything has remained connected with everything else. As a result of the ongoing 'disciplinification' of universities, however, this important insight, familiar enough to Alexander von Humboldt, was lost."[21] Modern education blinkered the educated, creating the world of mutually uncomprehending scholarly tribes that C.P. Snow lamented in his famous 1959 Rede lecture on "The Two Cultures". In 1963, Snow wrote:

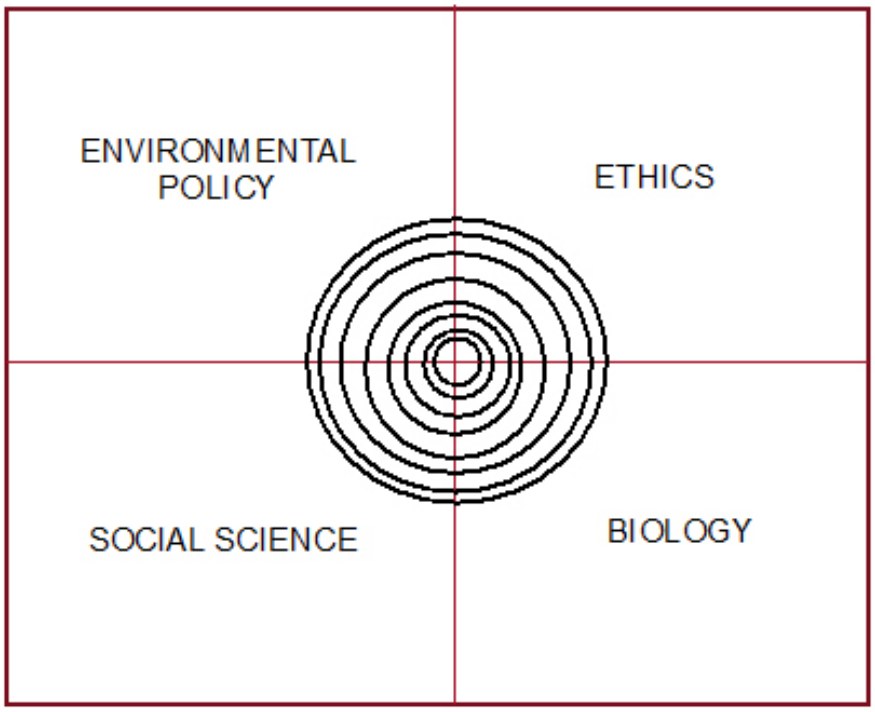
> Persons educated with the greatest intensity we know can no longer communicate with each other on the plane of their major intellectual concern. This is serious for our creative, intellectual and, above all, our normal life. It is leading us to interpret the past wrongly, to misjudge the present, and to deny our hopes of the future. It is making it difficult or impossible for us to take good action.[22]

In such a world, as Martin Kemp wrote: "a gulf of understanding has opened up by the time students enter university."[23]

The problem is not so much the existence of disciplines, as the fact that the disciplines have tended to block the free movement of ideas. In 1998, E.O. Wilson argued that the borders between disciplines were blocking fundamental research in many areas. The success of research within disciplines was creating more and more dead zones between disciplines, where new questions accumulated only to be ignored by discipline-based researchers, until they withered in an academic no-man's land of extreme aridity. Wilson used a diagram to make the point.

Here, each quadrant represents a distinct research world, with its own rules, its own criteria for good research, its own funding mechanisms, journals, and

Why Consilience is difficult:
a diagram adapted from E.O. Wilson, *Consilience*, p. 8



measures of prestige and success. But, he wrote, close to the borders between disciplines, "we find ourselves in an increasingly unstable and disorienting region. The ring closest to the intersection, where most real-world problems exist, is the one in which fundamental analysis is most needed."[24] Though vibrant and productive within their boundaries, the disciplines were creating intellectual dead zones at their borders. Insert into Wilson's diagram other disciplines such as Anthropology, Neuroscience, History, and Primatology and you find, in the dead zone at their borders, the most fundamental question of all for the Humanities: what is it that defines our own species and explains why we are so unusual?

What explains this sudden fragmentation of knowledge that both empowered and limited education and research for a century? Increasing government management of education and research, driven by the increased role of governments during the world wars, encouraged a focus on specific problems and a high degree of institutional compartmentalization. But two other powerful forces were also at work: the spectacular increase in new information in the 19th century; and scepticism about the failure of earlier attempts at intellectual unification.

Today, it is easy to forget how terrifying and destabilizing was the tsunami of new knowledge created by the earthquake of industrialization. In a famous passage in the Communist Manifesto, Marx and Engels wrote: "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,…" No universal systems or stories seemed robust enough to survive unscathed in a world of such intellectual turmoil, none of the ancient religious or philosophical systems, and not even the more modern systems of the great Enlightenment thinkers. The disciplines provided intellectual shelters from the hurricane of new knowledge.

The second reason for abandoning the unifying projects of the Enlightenment was that none of these projects really worked. The success of Newton's system was not matched in history or sociology or even in the sciences, and early in the twentieth century Einstein showed that even Newton's physics

needed adjusting. Besides, the French Revolutionary Terror, and the bloody history of the nineteenth century undermined the Enlightenment's intellectual optimism, by showing that Reason, science and new types of knowledge could serve oppression as well as progress. Scepticism was magnified by the world wars of the early twentieth century and the rise of totalitarian systems sustained by science and claiming to be built on Reason. One of the most influential modern critiques of Enlightenment thought, Horkheimer and Adorno's Dialectic of Enlightenment, was written in the shadow of the Nazi death camps, which had put modern scientific knowledge to the most evil of ends.[25]

In retrospect, most of the large nineteenth century systems and unifying stories do indeed look more like ideologies than science. That was because the science behind them was too thin to build robust intellectual systems, and had to be padded out with much speculative wadding. Though the nineteenth century did yield powerful unifying ideas, such as Darwin's theory of evolution, or Maxwell's unification of electricity and magnetism, there also appeared many pseudo-scientific systems of thought, such as phrenology, or Social Darwinism. These undermined the credibility of the Enlightenment project, and encouraged a turning away from unifying schema towards less ambitious scholarly agendas. The retreat from unifying projects was almost universal in the Humanities disciplines, which lacked the paradigm ideas that kept hopes of unification alive in the natural sciences. Historians reacted against the "scientific history" of Marx and his followers. And Anthropologists turned away from pseudo-scientific accounts of human progress, towards detailed studies of particular cultures. "In cleansing historical and cultural analysis of their nineteenth-century ideological baggage," write Shryock and Smail, "most of the high modern (and postmodern) versions of cultural anthropology and history turned their backs on the deep human past …"[26]

But the structure of distinct disciplines inhibited the search for deep unifying ideas even in the natural sciences. In 1944, Erwin Schrödinger wrote:

> … the spread, both in width and depth, of the multifarious branches of knowledge during the last hundred odd years has confronted us with a queer dilemma. 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; but, on the other hand, it has become next to impossible for a single mind fully to command more than a small specialized portion of it.[27]

Critiques of hyper-disciplinarity

As this passage suggests, there survived within the fragmented world of distinct scholarly disciplines a deep nostalgia for a lost world of intellectual cohesion. And it may be that the ideal of some sort of universalism survived better beyond the Atlantic world. Marxist traditions in the Soviet Union and China preserved the ideal of universal knowledge, though in forms that were archaic and constricted by censorship; but survival of the ideal may help explain the profoundly inter-disciplinary ideas of Soviet astrobiologists such as Iosif Shklovksy, and geologists such as Vladimir Vernadsky, who pioneered the idea of a biosphere.[28] And small numbers of scholars in many different parts of the world continued to insist on the importance of transcending discipline boundaries and preserving a sense of the underlying unity of knowledge and research.[29]

In the early twentieth century, and particularly in the Atlantic world, nostalgia for some sort of intellectual coherence shaped much modern art, literature, philosophy and scholarship. Yeats' poem, "The Second Coming", captures that nostalgia and the terror of living in a world without intellectual unity or meaning.

> 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 best lack all conviction, while the worst
> Are full of passionate intensity.

The yearning for a lost intellectual unity drove many scholarly attempts to cross disciplinary borders, but few made much headway because there was now little institutional support for genuinely transdisciplinary research, particularly in Europe and North America. Erwin Schrödinger wrote, forlornly:

> I can see no other escape from this dilemma (lest our true aim be lost for ever) than that some of us should venture to embark on a synthesis of facts and theories, albeit with second-hand and incomplete knowledge of some of them–and at the risk of making fools of ourselves.[30]

By the middle of the twentieth century, education, scholarship and research were so deeply embedded within the matrix of disciplines that even the most successful attempts at unification were no longer seen as unifying projects, but as attempts to travel between disciplines. It was the disciplines that now seemed fundamental rather than the networks of knowledge that linked them. Their borders seemed to map reality itself. As Wordsworth, a lifelong seeker of unity, wrote in *The Prelude* (Book 2):

> In weakness we create distinctions, then
> Deem that our puny boundaries are things
> Which we perceive, and not which we have made.

Attempts to unify knowledge were increasingly described as "interdisciplinary research". Interest in interdisciplinary research blossomed in the 1960s. The 1972 OECD report on interdisciplinarity that has already been mentioned argued that scepticism about science arose from "specialised applications of knowledge, without a corresponding development of the synthesising framework which can illuminate their side-effects and long-term implications."[31] Interest in interdisciplinary research was also driven by new research areas, such as genetics or gender studies, that overflowed existing disciplinary boundaries.

There were also some spectacular examples of the synergies that could be released by interdisciplinary expeditions. Erwin Schrödinger's attempt to cross disciplines in his book, What is Life?, provides a good example. Here was a physicist writing about a fundamental problem in biology. Schrödinger argued that life and reproduction must involve a sort of coding in large molecules, in which a small number of components could be arranged and re-arranged like letters in an alphabet. He suggested, therefore, that the chromosomes inside cell nuclei might each consist of what he called "an aperiodic crystal or solid".[32] That idea inspired a generation of biologists, including the discoverers of the structure of DNA. Indeed, Francis Crick, though originally a physicist, switched to biology and origin-of-life research after reading Schrödinger's book.[33]

By the 1970s, there were increasing demands for more interdisciplinary research. The first major conclusion of the influential 1972 OECD report on interdisciplinarity was that: "Interdisciplinary teaching and research are the key innovation points in universities," in part because interdisciplinarity can "help the drift of science and research towards unity". But the report's second major conclusion was that the scholarly disciplines made the quest for unity extremely difficult. "Introducing this innovation comes up against enormous difficulties …", above all because of "The organization of universities into monodisciplinary Schools or 'Faculties' which jealously protect their branch of knowledge …"[34]

The mid twentieth century vogue for interdisciplinarity generated new university and research structures and spawned new composite disciplines, such as biochemistry or environmental science. And that is why, today, some forms of

interdisciplinary research are familiar and well-funded. But the return to unifying projects was hesitant, partial and limited, and took several different forms. New typologies were constructed to describe different degrees of interdisciplinarity. The most widely used categories have been "Multidisciplinarity", "Interdisciplinarity" (in a non- generic sense) and "Transdisciplinarity".[35]

"Multidisciplinarity" refers to a loose linking of disciplines, often around a common problem or research agenda, while the individual disciplines "… continue to speak as separate voices in encyclopedic alignment. Underlying assumptions are not examined and the status quo remains intact." "Interdisciplinarity" refers to a closer integration of disciplines that: "integrates separate data, methods, tools, concepts theories and perspectives in order to answer a question, solve a problem, or address a topic that is too broad or complex to be dealt with by one discipline. … in interdisciplinary fields a new body of knowledge emerges."[36]

Finally, "Transdisciplinarity" takes us even closer to the unifying projects of the Enlightenment. Transdisciplinarity refers to an even closer integration of methods and insights from different disciplines that points towards "an over-arching synthesis that transcends the narrow scope of disciplinary worldviews."[37] Julie Klein describes the most ambitious forms of transciplinarity as: "… the epistemological quest for systematic integration of knowledge".[38] In a world of disciplinary fiefdoms, transdisciplinarity, the most integrated form of interdisciplinary scholarship, made the least headway. It remains rare and poorly funded, and has had a limited impact on most of the Academy, despite the existence of some specially designed transdisciplinary institutions such as the Santa Fe Institute for Complexity studies.

The re-emergence of unifying projects from the late twentieth century

Despite all this, in the late twentieth century and early twenty first century there have been some promising signs of a return to the unifying projects of the past.

Transdisciplinary thought and research made most headway in the Natural Sciences, where they were buoyed by new paradigm ideas, including Big Bang Cosmology, the Standard Model of Particle Physics, Plate Tectonics and the modern Darwinian synthesis.[39] Some scientists even began to dream of super-paradigms or "Grand Unified Theories" that would capture the fundamental rules by which our Universe was constructed. But the new paradigms also encouraged the quest for narrative coherence, because they were all historical in nature. They all described how the Universe, planet earth, and life had evolved over vast periods of time. The Harvard astronomer, Harlow Shapley (who once described the splitting of knowledge between disciplines as "education-defeating"), advocated for university curricula that: "would present the history of the universe and mankind as deduced from geology, cosmogony, paleontology, anthropology, comparative neurology, political history, and so on. … wide integration is the essential key."[40] And he was as good as his word, teaching such courses at Harvard for several decades, before his successor, Carl Sagan, built from them a wildly popular television series, "Cosmos".[41] Similar courses were taught in the Soviet Union by Iosif Shklovksy, in France by Hubert Reeves, and in Austria by Erich Jantsch.[42]

In the late twentieth century, several scientists wrote synthetic works that combined conceptual and narrative coherence over large areas of knowledge. They included histories of the earth by Preston Cloud, histories of the universe by the astronomers, George Field and Eric Chaisson, and the astrophysicists, Erich Jantsch and Siegfried Kutter.[43] In the 1990s, Eric

Chaisson wrote a history of the universe built around the central theme of increasing complexity, driven by increasingly dense flows of energy.[44] He called his unifying project "Cosmic Evolution", using a phrase first introduced in the late 1970s by George Field.[45] Fred Spier would later offer a theory of universal history that focussed on the emergence of "regimes" or semi-stable structures of many different kinds, an idea that had been partially prefigured in the work of Erich Jantsch.[46]

Scholars in the Humanities took longer to embark on serious transdisciplinary journeys, partly because the Humanities did not generate paradigm ideas as persuasive as those that emerged within the Natural Sciences. The unifying ideas that did emerge within disciplines such as Economics or Sociology or Archaeology were always contested, unlike some of the big ideas in the natural sciences, which were so widely accepted that they achieved the status of Kuhnian paradigms.[47] The "pre-paradigm" nature of most Humanities disciplines encouraged a focus on specifics, and a deep scepticism about attempts at intellectual unification, or the construction of "grand narratives".

Nevertheless, even in the Humanities disciplines, there were large, general problems, such as the rapidly increasing human impact on the biosphere, that encouraged some researchers to travel tentatively between disciplines.[48] And the historical narratives emerging within the natural sciences encouraged some scholars to seek links between their own historical narratives and the large-scale narratives emerging within Cosmology, Geology and Palaeontology. Though most historians remained sceptical of the idea of universal history, fearing a return to the unsuccessful historical schema of the nineteenth century, some were attracted by the challenge of linking human history to the emerging histories of the biosphere, planet earth and the Universe as a whole. They were inspired, not only by the new unifying narratives being constructed within the natural sciences, but also by the fact that the science was so much richer and more rigorous than it had been in the nineteenth century. That encouraged hopes for unifying stories free of most of the non-scientific intellectual baggage of the less successful nineteenth century systems.

New dating methods also transformed the task of constructing universal histories. When H.G. Wells wrote a history of the Universe in the 1920s, he could offer no reliable absolute dates for any event before the first Greek Olympiad. All earlier events disappeared into a chronological fog. In the 1950s, new dating techniques were developed, based on the breakdown of radioactive materials. Radiometric dating allowed the construction of reliable chronologies reaching, eventually, to the origins of the Universe. These dates provided the chronological spine for a rigorous, science-based modern origin story.[49]

To scholars from the Humanities, unification meant, almost inevitably, narrative unification rather than the conceptual unification sought by scholars in the natural sciences. For scholars in the Humanities, the challenge was to link stories told in many different disciplines into a coherent universal account of the past. What larger plot lines could be seen, and what new themes and forms of coherence would emerge if you tried to weave together the stories told by cosmologists, astronomers, geologists, biochemists, palaeontologists, anthropologists and historians?

My own experience of approaching these challenges as a historian may be fairly typical. When I first tried to teach a big history course embracing the whole of time, in 1989, I invited scholars from many different disciplines to lecture on the core ideas of their disciplines. My colleagues and I watched to see what would come out of the mix. What we got was a brilliant tour of modern paradigms alongside a rather loose account of human history. But the stories did not cohere, because lecturers spoke to the major themes

of their disciplines, used the methods and jargon with which they were familiar, and had little time to build bridges between disciplines. I began to fear that big history courses would remain "interdisciplinary" in the most limited sense. They could not transcend the disciplines, and could, at best, serve up a sort of intellectual smorgasbord.

Over several years, though, broader plot-lines and a deeper coherence began to appear. It became apparent that one major narrative theme was the emergence of many forms of complexity, at many different scales, from galaxies to viruses to human civilizations. That theme raised deep questions about the creativity of the Universe as a whole, and about the relationship between complexity in the human world and complexity in the biosphere and the Universe as a whole. Watching unifying themes emerge over several years was a bit like watching a developing photograph in the chemical bath of a traditional photographic dark room. And the gradual appearance of unifying themes showed that the difficulties of seeking unified knowledge arose not from the intrinsic difficulties of the project, so much as from the habits of thought that dominated a world of distinct scholarly disciplines.

Since the late twentieth century, many scholars have taken up the challenge of constructing "big histories" or modern origin stories, and they have done so in many different parts of the world which suggests that there is an emerging "global conjuncture" around the idea of such projects.[50] Today, there is a growing scholarly literature on big history, and big history courses are being taught in a number of universities, mostly in the USA, Australia and the Netherlands. Online courses in big history have also been developed for high schools, through the "Big History Project" (generously supported by Bill Gates) and, in 2018, through "Big History School" (supported by Macquarie University), which includes a Primary School curriculum in big history.[51]

New transdisciplinary projects and new research agendas

The final section of this essay is frankly speculative. If the changes described in the previous section are early signs of a scholarly return to more transdisciplinary research and thought, what impact will this have on the research landscape?

A world in which the unification of knowledge is taken seriously will be intellectually more balanced than today's world. The disciplines will survive, not just because of institutional inertia, but also because they serve many useful functions. And they will continue to shape research at smaller scales. But as transdisciplinary research becomes more important, the disciplines will have to become more sensitive to developments in neighbouring fields and in scholarship as a whole. Disciplinary boundaries will have to become more flexible, more permeable and more open to transformative changes.

To support, fund, and offer career paths to the increasing number of scholars drawn to transdisciplinary problems, new institutions will be needed to link disciplines and encourage more traffic between them. Amongst those most drawn to unifying projects, something of C.P. Snow's distinction between the cultures of the sciences and humanities will surely survive. But the differences will no longer arise from mutual incomprehension, but rather from sustained dialogue, in which some scholars will focus mainly on the narrative coherence between different fields, while others focus on the conceptual challenge of teasing out unifying paradigms.

A more unified knowledge world will transform school syllabi. But the changes need not be complex, and most of the existing infrastructure of education will remain in place. Most traditional disciplines will survive. But new, unifying disciplines will emerge, such as "Big History", which can help students see the underlying coherence of modern knowledge, and

the many links between traditional disciplines. Such courses already exist and they offer students the metaphorical equivalent of a journey to the top of the mountain, from where they can see more clearly what links different disciplines as well as what divides them. If such courses were to become standard components of school curricula throughout the world, they could provide students, as traditional origin stories once did, with a coherent vision that they could take with them into adult life.

In Universities, too, teaching within existing disciplines will no longer create intellectual blinkers if students are also exposed to courses that help them see the unity beneath modern disciplines. Such courses are already being taught in many universities, and there already exist rich resources, both printed and electronic, to support their teaching.

A return to the unifying project of the Enlightenment may have its greatest impact in advanced research environments, which is where they have had the least impact so far. Today, scholars attracted by the challenges of transdisciplinary research struggle to gain recognition, to raise funding, and to find scholarly support. But a world that takes such projects more seriously will surely take more seriously the intellectual and institutional challenges faced by those researchers most interested in transdisciplinary research.

What will unifying research projects look like? We already have some answers because paradigm builders such as Darwin and Einstein have shown that there are deep, powerful unifying ideas waiting to be discovered by those who look for them. And there are areas of research where the need for unifying ideas is apparent to everyone, such as the challenge of linking Relativity Theory and Quantum Theory. Both theories work spectacularly well, yet one assumes a granular universe while the other does not. What are we missing? In the Humanities, the question that may drive unifying agendas most powerfully concerns the distinctiveness of our own species. What makes humans different, so different that our species is now dominating change in the biosphere?[52]

These large questions offer good models for unifying research in general, because to pursue them, scholars will have to link methods, insights, concepts, terminology and perspectives from many different disciplines. Their task will be to translate between disciplines. Can you translate the concept of entropy, which does extraordinarily powerful work in the natural sciences, into the Humanities? Is the historian's "decline and fall" similar to the physicist's "entropy"? Is there enough common ground between the two concepts that, with some tweaking we may find ways of describing entropy that can inform research in the humanities? Much the same is true of concepts like information (do acoustic engineers, quantum theorists, geneticists and historians mean the same thing when they use the word?), or complexity, or energy.

The task is also to tweak how concepts are used at different scales, because many concepts work well at some scales and less well at others.[53] One of the most fundamental problems in contemporary science is how to make Quantum Physics work not just at the atomic scale but also at the cosmological scales of relativity? For the historian, concepts such as energy or information are too general to be helpful in most types of historical research, so the abstract concepts do not loom large in historical discussions, though specific forms of energy and information are woven into all historical narratives. Can we link these different levels of explanation, and will doing so prove illuminating?[54] The transdisciplinary challenge here is to check that the concepts used at different levels are aligned logically. That is a bit like assembling a conceptual ladder, all of whose rungs are part of the same system even though particular users may use a small part of the ladder. Or perhaps a better

metaphor is a Mandelbrot set, in which each level seems very different from other levels despite some eerie similarities and despite the fact that all levels are generated by the same equation.

There are huge intellectual synergies awaiting scholars who can reformulate fundamental ideas so as to extend their reach and the amount of useful intellectual work they can do. Network theory is another field that promises huge synergies if its methods and ideas can be extended beyond their existing range. I have tried myself to use network theory to understand the accumulation of knowledge within and between different types of human communities, and the Israeli historian, Irad Malkin, has shown how network theory can illuminate our understanding of ancient Greece.[55]

In addition to re-working and extending existing concepts, unifying research projects will surely generate new unifying concepts as well, ideas that can do useful work across large intellectual spaces. Many such ideas also exist. Eric Chaisson has explored the idea that the density of energy flows may provide one way of measuring and explaining different levels of complexity in a Universe in which the upper levels of complexity seem to have increased over time. Is this an idea that can help us make sense of phenomena as diverse as stars, solar systems, cellular life, ecosystems and human history? Fred Spier has argued for the usefulness of the idea of "regimes" in universal history. There have been many attempts to extend the concept of natural selection beyond the biological realm that first generated it, as a way of explaining increasing complexity through what Richard Dawkins describes as Universal Darwinism. In a famous 1960 essay called "Blind Variation and Selective Retention", Donald Campbell argued that, whatever the domain, evolution needs "a mechanism for introducing variation, a consistent selection process, and a mechanism for preserving and reproducing the selected variations."[56] Do similar mechanisms explain emerging complexity in human cultures, or even in Cosmology, or in Quantum Physics, as some have argued?[57] Whatever answers eventually emerge to such questions, these are rich and profound research agendas that will be very hard to pursue successfully until the world of scholarship returns once more to the unifying projects of the Enlightenment.

Unifying research agendas, requiring plenty of conceptual translation, will also emerge in response to complex, transdisciplinary problems. Environmental history offers a good model, as historians and climatologists and ecologists and scholars in many different fields have reached out towards each other to create what is now a vibrant and strategic transdisciplinary research field. Closely related, and driven by similar synergies is the rapidly expanding field of "Anthropocene" studies. Understanding the planet-changing impacts of human activities in the twentieth century is a task that requires the sharing of insights and perspectives from historians, economists, climatologists, palaeontologists, biologists, geologists, and more.

These guesses about the research agendas and approaches of a world that takes seriously Schrödinger's "longing for unified, all-embracing knowledge" are all based on developments that are already apparent. Today's scholarly world may be slowly recovering the ancient balance between detailed and unifying knowledge. And doing that is increasingly urgent in a world that faces the colossal challenge of managing an entire planet, a challenge that cannot even be seen clearly through the narrow lenses of existing scholarly disciplines. The discipline-based scholarly world of the twentieth century generated such rich knowledge in so many fields that it should now be possible to return to the unifying projects of the Enlightenment, and tackle the new problems of the Anthropocene with a rigour and richness, and a global scholarly reach, that was unthinkable before the twenty first century.

Endnotes

1 My thanks to Ian Crawford, Marnie Hughes-Warrington, Barry Rodrigue, and Nobuo Tsujimura for helpful comments on earlier drafts of this paper.

2 I will use the label "big history" and "cosmic evolution" to describe different approaches to the same unifying project. There is a rapidly growing literature. 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, and *Origin Story: A Big History of Everything*, Little, Brown and Penguin, 2018; 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 Rodrigue, Leonid Grinin and Andrey Korotayev, eds., F*rom Big Bang to Galactic Civilizations: A Big History Anthology*, Vol. 1, *Our Place in the Universe*, Delhi: Primus Books, 2015; a beautifully illustrated overview, Macquarie University Big History Institute, *Big History*, London: DK books, 2016; and the forthcoming Routledge *Companion to Big History*, ed. Craig Benjamin, Esther Quaedackers and David Baker, Routledge, 2021.

3 This essay expands on and develops arguments presented earlier in David Christian, "The Return of Universal History," *History and Theory*, Theme Issue, 49 (December 2010), 5-26, and "What is Big History?", *Journal of Big History*, Vol. 1, No. 1 (2017), 4-19.

4 All quotes from Erwin Schrödinger, *What is Life?*, Cambridge: Cambridge University Press, 2000, p. 1 [first publ. 1944]

5 I have made this argument in David Christian, *Origin Story: A Big History of Everything*, London: Penguin, and New York: Little, Brown, 2018. For an introduction to modern theories of "myth", and their relationship to modern thought and science, see Robert Segal, *Myth: A Very Short Introduction*, 2nd ed., Oxford University Press, 2015.

6 "In our creation myths we tell the world, or at least ourselves, who we are." David Leeming, *Myth: A Biography of Belief*, New York: Oxford University Press, 2002, Kindle ed., p. 36.

7 Marie-Louise von Franz, *Creation Myths*, Rev. Ed., Boulder Colorado: Shambala, 1995. Ch. 1.

8 Richard S. Westfall, *The Life of Isaac Newton*, Cambridge: Cambridge University Press, 1993, 259; Newton later abandoned the metaphor of a sensorium, but continued to believe that God was literally "omnipresent" in the Universe.

9 Richard S. Westfall, *The Life of Isaac Newton*, Cambridge: Cambridge University Press, 1993.

10 That all myths evolve is the core argument of David Leeming, *Myth: A Biography of Belief*, New York: OUP, 2002; Tony Swain, *A Place for Strangers: Towards a History of Australian Aboriginal Being*, Cambridge: CUP, 1993 explores how indigenous Australian mythologies changed when faced with new, introduced origin stories, including those of Christianity.

11 David Hume, A Treatise of Human Nature, Introduction.

12 Adapted from the dual-language text of Kant's "What is Enlightenment?", at https://bdfwia.github.io/bdfwia.html.

13 Anthony Pagden, *The Enlightenment: And Why it Still Matters*, Oxford: Oxford University Press, 2013, Kindle ed., p. 147 ff.

14 In an important article on the emergence of Big History, Eric Chaisson offers a similar, but not identical distinction, when talking of "two ways up the mountain." Eric Chaisson, "Big History's Risk and Challenge", *Expositions*, 8.1 (2014) 85–95, https://expositions.journals.villanova.edu/article/view/1774 from 85-6.

15 Fred Spier, "Big history: the emergence of a novel interdisciplinary approach", *Interdisciplinary Science Reviews*, 33 (2008):2, 141-152, from pp. 143-4; On Humboldt as a universal historian, 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.)

16 The Ranke quote is from "A Fragment from the 1860's", in Fritz Stern, ed., *The Varieties of History: From Voltaire to the Present*, Cleveland and New York: World Publishing Company, 1956, pp. 61-2.

17 There are good introductory descriptions of the emergence of modern scholarly disciplines in Bjorn Wittrock, "Discipline Formation in the Social Sciences", from *International Encyclopedia of the Social and Behavioural Sciences*, ed. James D. Wright, 2nd ed., Elsevier, 2015, 485-90; and Rudolf Stichweh, "Scientific Disciplines, History of", from *International Encyclopedia of the Social and Behavioural Sciences*, ed. James D. Wright, 2nd ed., Elsevier, 2015, 287-290.

18 The metaphor of autonomous fiefdoms comes from Léo Apostel, Guy Berger, Asa Briggs, Guy Michaud, eds., *Interdisciplinarity: Problems of Teaching and Research in Universities*, Paris: OECD, 1972, pp. 9.

19 Stephen Turner, "Knowledge Formations: An Analytic Framework", Ch. 2 of *The Oxford Handbook of Interdisciplinarity*, 2nd ed., Oxford: OUP, 2017, p. 9; Turner offers a useful short survey of the evolution of disciplines.

20 Stephen Turner, "Knowledge Formations: An Analytic Framework", Ch. 2 of *The Oxford Handbook of Interdisciplinarity*, 2nd ed., Oxford: OUP, 2017, p. 18.

21 Fred Spier, "Big history: the emergence of a novel interdisciplinary approach", *Interdisciplinary Science Reviews*, 33:2, 141-152, from pp. 144.

22 Cited from C. P. Snow, "The Two Cultures and the Scientific Revolution", in C. P. Snow, *Public Affairs* (London and Basingstoke: Macmillan, 1971; 1st published 1959), pp. 13-46.

23 Both quotations from an essay on the 50th anniversary of C. P. Snow's lecture on "The Two Cultures": Martin Kemp, "Dissecting the Two Cultures", *Nature*, Vol. 459/7, May 2009, pp. 32-3; my thanks to Ian Crawford for this reference.

24 From E. O. Wilson, *Consilience: The Unity of Knowledge*, London: Abacus, 1998, p. 8.

25 Max Horkheimer and Theodor W. Adorno, *Dialectic of Enlightenment*, translated by Edmund Jephcott, Stanford University Press, 2002.

26 Andrew Shryock and Daniel Lord Smail, *Deep History: The Architecture of Past and Present*, Berkeley: UC Press, 2011, Kindle ed, loc. 294.

27 Erwin Schrödinger, *What is Life?*, Cambridge: CUP, 2000, p. 1 [first publ. 1944].

28 On Soviet writing on big history, see Akop P. Nazaretyan, "Western and Russian Traditions of Big History: A Philosophical Insight", in *Journal for General Philosophy of Science* (2005) 36: 63–80; on Soviet pioneers of astrobiology, see David Grinspoon, *Earth in Human Hands: Shaping our Planet's Future*, New York: Grand Central Publishing, 2016, pp. 301-26; Shklovksy would later collaborate with Carl Sagan; on Vernadsky, a good introduction is V. I. Vernadsky, *The Biosphere*, New York: Springer-Verlag, 1998.

29 A famous example is Jawaharlal Nehru, *Glimpses of World History*, a world history published in 1942

and written in prison.

30 Erwin Schrödinger, *What is Life?*, Cambridge: CUP, 2000, p. 1 [first publ. 1944].

31 Léo Apostel, Guy Berger, Asa Briggs, Guy Michaud, eds., *Interdisciplinarity: Problems of Teaching and Research in Universities*, Paris: OECD, 1972, p. 10.

32 Erwin Schrödinger, *What is Life?*, Cambridge: CUP, 2000, 60-62.

33 James D. Watson, *The Double Helix: A Personal Account of the Discovery of the Structure of DNA*, Penguin books, 1973, p. 23.

34 Léo Apostel, Guy Berger, Asa Briggs, Guy Michaud, eds., *Interdisciplinarity: Problems of Teaching and Research in Universities*, Paris: OECD, 1972, p. 12.

35 Léo Apostel, Guy Berger, Asa Briggs, Guy Michaud, eds., *Interdisciplinarity: Problems of Teaching and Research in Universities*, Paris: OECD, 1972, pp. 25-6.

36 These definitions from Julie Klein, "Interdisciplinarity", in Carl Mitcham, ed., *Encyclopedia of Science, Technology and Ethics*, Detroit, MI: Macmillan reference, 2005, 1034-37, from pages 1034-35; and see Julie Klein, "Typologies of Interdisciplinarity: The Boundary Work of Definition", Ch. 3 of *The Oxford Handbook of Interdisciplinarity*, 2nd ed., Oxford: OUP, 2017.

37 Julie Klein, "Interdisciplinarity", in Carl Mitcham, ed., *Encyclopedia of Science, Technology and Ethics*, Detroit, MI: Macmillan reference, 2005, 1034-37, from pages 1034-35.

38 Julie Klein, "Typologies of Interdisciplinarity: The Boundary Work of Definition", Ch. 3 of *The Oxford Handbook of Interdisciplinarity*, 2nd ed., Oxford: OUP, 2017, p. 29.

39 For more examples of such unifying approaches in the natural sciences, see Ian Crawford, (2019) "Widening Perspectives: The Intellectual and Social Benefits of Astrobiology, Big History, and the Exploration of Space." *Journal of Big History*, III(3); 163 - 182, in this volume.

40 Harlow Shapley, *The View from a Distant Star: Man's Future in the Universe*. Dell Publishing, New York, 1963, p. 135-6, cited from Ian Crawford, "Widening Perspectives", this volume.

41 Eric Chaisson, "Big History's Risk and Challenge", *Expositions*, 8.1 (2014) 85–95, p. 87.

42 Eric Chaisson, "Big History's Risk and Challenge", Expositions, 8.1 (2014) 85–95, https://expositions.journals.villanova.edu/article/view/1774, p. 87.

43 Fred Spier, "Big history: the emergence of a novel interdisciplinary approach", *Interdisciplinary Science Reviews*, 33:2, 141-152, from pp. 144.

44 Eric Chaisson, *Cosmic Evolution: the Rise of Complexity in Nature*, Cambridge, Mass: Harvard University Press, 2001.

45 See George Field, Gerrit Verschuur and Cyril Ponnamperuma, *Cosmic Evolution: An Introduction to Astronomy*, Boston: Houghton Mifflin, 1978 and E.J. Chaisson, "Relating Big History to Cosmic Evolution," in *From Big Bang to Galactic Civilizations: A Big History Anthology*, Vol II, B. Rodrigue, L. Grinin, and A. Korotayev (eds.), pp 17-30, Primus Books, Delhi, 2016.

46 Fred Spier, *The Structure of Big History: From the Big Bang until Today*, Amsterdam: Amsterdam University Press, 1996.

47 Thomas Kuhn, *The Structure of Scientific Revolutions*, 2nd ed., Chicago: University of Chicago Press, 1970.

48 Julie Klein, "Une taxinomie de l'interdisciplinarité", in *Nouvelles perspectives en sciences sociales*, Volume 7, numéro 1, octobre 2011, pp. 15-48, see p. 15.

49 A crucial work here was Colin Renfrew's classic

study of the implications of radiometric dating for archaeology: 1973, *Before Civilisation, the Radiocarbon Revolution and Prehistoric Europe*, London: Pimlico, 1973. On the chronometric revolution, see also 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, pp. 441-462.

50 See Barry Rodrigue, 'The Study of All Existence: Big History, Universal Studies and the Global Conjuncture', pp. 15-34, in *Big History and Universal Consciousness*, ed. Barry Rodrigue, special edition of *The International Journal for the Transformation of Consciousness* 3 (1), June 2017.

51 These are available, respectively, at: https://www.bighistoryproject.com/home and https://school.bighistoryproject.com/bhplive.

52 My own attempt at such ideas is the notion of "Collective Learning", which I have developed in Maps of Time and elsewhere; that idea is close to, and overlaps with many other attempts to tackle the same question; see Alex Mesoudi, *Cultural Evolution: How Darwinian Theory can Explain Human Culture and Synthesize the Social Sciences*, Chicago and London: University of Chicago Press, 2011, for a fine recent survey of the rich body of research surveying cultural change from a Darwinian perspective.

53 See David Christian, "Scales", in Marnie Hughes-Warrington, ed., *Advances in World History*, Basingstoke: Palgrave/Macmillan, 2005, 64-89.

54 I have attempted to tease out links between complexity, flows of energy and information at several different scales in Christian, "Complexity, Energy and Information in Big History and Human History", in Charles Weller, ed., *21st-Century Narratives of World History: Global and Multidisciplinary Perspectives*, Palgrave/Macmillan, 2017, pp. 111-42.

55 Irad Malkin, *A Small Greek World: Networks in the Ancient Mediterranean*, OUP, 2011.

56 Donald T. Campbell, "Blind Variation and Selective Retention in Creative Thought as in other Knowledge Processes", *Psychological Review*, 67 (1960), No. 6: 380-400, from p. 381.

57 David Christian, "Swimming Upstream: Universal Darwinism and Human History", in Leonid Grinin, David Baker, Esther Quaedackers, and Andrey Korotayev eds., *Teaching & Researching Big History: Exploring a New Scholarly Field*, 'Uchitel' Publishing House, Volgograd, 2014, ISBN: ISBN 978-5-7057-4027-7, pp. 19-40.