DEEP FUTURE of BIG HISTORY:

Cultural Evolution, Technoculture, and Omega Civilization

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(v1.3., September 22, 2014)

ABSTRACT: The study of big history attempts to identify major trends and processes throughout the development and evolution of the local universe. Big history has allowed for the integration of many disparate academic subjects, revealing a science and art of studying the emergence of complexity, the relation between evolutionary processes, and the cosmic context of the human experience. Current big historical data and theory identifies "Three Eras" of ordered and organizing complexity regimes: Physical, Biological, and Cultural Eras. These Eras change as a consequence of "Three Evolutionary Processes": Physical, Biological, and Cultural Evolution. Contemporary science has developed the necessary tools to extrapolate and make predictions about the future of both the Physical and Biological Eras of evolution, but the potential future of the Cultural Era of evolution remains mysterious, yet intriguing. Cosmological theory predicts that all Eras will eventually end in thermodynamic equilibrium, or "heat death". However, throughout the history of the cosmos, complexity and order have steadily increased in our local region of the universe, drifting further and further from simplicity and thermodynamic equilibrium in the process. Physical systems achieve higher order through gravitationally influenced energy flows; and living systems achieve higher organization through an information-based regulation of energy flows. Both processes contribute to the cosmic evolutionary trends of increased material integration, variation, and space-time compression. Cosmic evolution is fundamentally unified throughout this complexification process, manifesting as physicochemical, biochemical, and biocultural evolution, respectively. By situating biocultural evolution within the context of cosmic evolution, as well as extrapolating the trend of increasing complexity, I attempt to construct a useful model for understanding the human deep future. This includes an addition and/or reformulation of technological singularity theory with the concept "atechnogenesis", as well as an in-depth analysis of the potential properties of a "technocultural" world. Furthermore, I explore the potential deep futures of intelligence, and extrapolate towards two hypothetical versions of an "Omega Civilization": Expansion and Transcension. These models and predictions have consequences for our understanding of the deep future, which may in turn significantly affect the future of many cultural institutions. In this work I also attempt to build upon the big historical approach, which emphasizes the integration of knowledge from the sciences and humanities. Of course, in this extrapolation and speculation I make a fundamental assumption that the frontier of cosmic evolution will not suffer from either an internal or an external existential crisis.

Contents:

1. Introduction

The purpose of this paper is to explore the “Deep Future” of “Big History”, in-as-far as it can be explored, given A) lack of empirical data, B) inability to test future predictions, and C) an incomplete knowledge of local and global physical, biological, and cultural processes currently in operation. However, I believe we can start to gain a deeper understanding of potential future trends and processes by drawing upon the theoretical progress that has been made in the early stages of inquiry related to cosmic evolution throughout big history.

The most important and novel addition to the literature offered in this paper involves taking cultural function and structure seriously as a natural evolutionary phenomenon of equal importance to the hierarchy of cosmic processes that include physicochemical and biochemical forms of evolutionary change. The failure to understand culture, and particularly the relationship between biology and culture as part of cosmic evolution, may be the primary failing of science in the modern world. This is an important factor in holding back progress in our understanding of the future of humanity. Therefore, in my approach to the deep future of big history I focus on the emergence of the Cultural Era (for a deeper analysis of the relationship between biology and culture as modes of reproduction in direct competition with one another, see: Last 2014a). This biocultural reproductive nature of the human presents us with a peculiar cosmic evolutionary relationship offering important clues to the future of reproduction. And considering that reproduction has driven evolutionary change since the emergence of life, revealing its likely future trajectory will help us understand the future of big history in a novel way.

This approach to culture as part of a cosmic evolutionary process is part of an emerging realization that we need to understand the “nature of cosmic culture” (see: Dick & Lupisella 2009), as well as the “future of culture” (see: Dick 2009a; Stewart 2009). Many theorists have explicitly stated that predicting the future of culture is impossible, however as someone who has studied futurist theory, cosmic evolutionary theory, as well as the nature of the biocultural relationship, I feel that this position is shortsighted and uninformed. Instead, our inability to understand the nature of cultural reproduction and its future implications is likely a product of the “two cultures” divide that has pervaded academic inquiry for decades (see: Snow 1959; Kauffman 2010). This divide destroys the construction of unifying conversation between diverse fields within biology and anthropology, and more broadly between the “physical/life sciences” and “social sciences/humanities”. These divisions, which are likely simple products of intellectual history, prevent an understanding of the whole of Nature. But if we understood the cosmic nature of culture this divide may be unified, or at least we could have a traversable bridge.

Therefore, to effectively understand the nature of culture and the future of big history we necessarily require a holistic approach that appreciates the unity of all human knowledge, as well as the “naturalness” of all processes, including culture, technology, language, and mind. This exploration also requires scientifically grounded extrapolation and speculation when confronting questions that most scientists, philosophers, and historians would deem to be unknowable with any degree of certainty. However, we live in unprecedented times when compared to any known time period throughout cosmic history, and consequently, we need new ideas to open conversation about what we are and where we may be going (Wiener 1963, p. 5-6):

"It is the part of the scientist to entertain heretical and forbidden opinions experimentally, even if [s/]he is finally to reject them. […] It is a serious exercise, and should be undertaken in all earnestness: it is only when it involves a real risk of heresy that there is any point to it."

In this attempt I acknowledge that many before me have contemplated, speculated, and extrapolated contemporary evolutionary processes into the deep future (Adams 1909; Teilhard de Chardin 1955; Ulam 1958; Good 1965; Turchin 1977; Russell 1982; Vinge 1993; Sagan 1997). The continuation of scientific futurism as an intellectual tradition into the new century has demonstrated that it is a worthwhile endeavor in which real academic progress can be made (see: Lloyd 2000, 2006; Rosnay 2000; Stewart 2000, 2010, 2014; Kurzweil 2001, 2005; Goertzel 2002, 2003; Heylighen 2007a, 2007b, 2014a; Hanson 2008; Smart 2009, 2012; Drexler 2013; Blackford & Broderick 2014; Kaku 2014; Veitas & Weinbaum 2014; Vidal 2014a).

I hope that in my attempt to engage with the historical dialogue on the deep future I prove that I have not forgotten the cultural giants that precede my own attempt. I also hope the reader will feel that I have not pushed speculation too far, as I do base this exploration within the foundations of evidence-based theoretical progress related to the study of big history (see: Sagan 1977; Smith & Szathmáry 1995, 2000; Spier 1996, 2011; Chaisson 2001, 2011a, 2011b; Corning 2002, 2005, 2007; Christian 2004; Kurzweil 2005; Niele 2005; Aunger 2007a, 2007b; Dick & Lupisella 2009; Smart 2009, 2012; Heylighen 2012a; Lineweaver et al. 2013a; Vidal 2014a); although I do push.

Finally, like other works on the deep future, I think this analysis will leave us with far more questions than answers when it comes to the deepest reaches of the future. But it is important to live in the questions, not in the answers. There are likely to be many worldview-shattering revolutions that still await our species. It is not the case that there are no big surprises left in Nature. However, regardless of whether my approach proves useful, I think an analysis of cultural evolution within the cosmic arena gives us tremendous reason to cherish our collective biocultural history. We are the inheritors of a deep and interconnected cosmic process, and find ourselves awkwardly navigating the highest levels of complexity our local region of space-time has ever known; within this evolutionary labyrinth big history may offer a light.

2. Big History

Big history is the study of the human past, within the framework of cosmic history (see: Christian 2004; Spier 2011). This endeavor attempts to utilize the entire collective body of human knowledge in order to construct a deeper understanding of all natural processes (e.g., Aunger 2007a, 2007b; Chaisson 2011a, 2011b) from Big Bang to Global Civilization (e.g., Rodrigue et al. 2012). In this attempt, cosmic evolution as a subject has emerged as a theoretical branch of study that attempts to understand all cosmic process throughout space-time-energy-matter (STEM) (Spier 2005; Chaissin 2012a). Both big history and cosmic evolution share the goal of providing a sense of common origin and holistic unity for our species with all Nature (e.g., Sagan 1977, 1980, 1997; Chaisson 1981, 2001, 2005; Bloom 2000; Christian 2004; Niele 2005; Dick 2009b; Kauffman 2010; Spier 2011).

Therefore, the emergence of big history and cosmic evolution represent more than just new silos of academic inquiry; these subjects consume silos, and have an important role to play in the ongoing construction of an inclusive global and cosmic worldview for the whole of humanity (e.g., Christian

2004, Dick 2009b; Vidal 2014a). Such worldview structures can help the human species contextualize modern challenges within the broadest contexts (e.g., Niele 2005; Spier 2011), and allow for the construction of future visions of humanity that represent practically realizable utopias (e.g., Heylighen 2002), or help us potentially discover processes and trends to guide evolutionary cosmic goals and purpose on deeper scales of space-time (e.g., Turchin 1977; Stewart 2000; Kurzweil 2005; Vidal 2014a).

2.1. History of Big History

The study of big history as an intellectual tradition can be understood as both old and new. The subject is old because we have evidence of humans constructing complex physical and metaphysical narratives, and thinking about natural explanations for the existence and the world, for as long as we have evidence of writing (Frietas 1975-79, 2008). In fact, this narrative tradition may have been manifest in the human species from the dawn of complex material culture (North 2008), as all modern human groups develop cosmic cultural worldview structures (Blainey 2010), regardless of ecological organization. Consequently, the origin of this behaviour is hypothesized to have emerged in concert with the emergence of full linguistic capabilities (Dunbar 2009), as the formation of a human worldview is deeply interconnected with the formation of the linguistic domain (Underhill 2009). The ramifications of this speculation suggests that “big history” in some form could represent a cultural archetype of human worldviews that is at least as old as the emergence of modern humans, *Homo sapiens sapiens* (~150-200 thousand years ago) (e.g., White et al. 2003; McDougall 2005).

However, the early origins of academic big history can be found in the construction of empirically based cosmic narratives. These types of histories, from various scientific and philosophical perspectives, started to emerge in the 19th century (e.g., Lamarck 1809; Chambers 1844; Humboldt 1845; Fiske 1874; Spencer 1896). Early big history narratives – like many of the narratives constructed by religious, spiritual, and philosophical perspectives before the modern world – were always concerned with the human relationship to life and the cosmos. In these works central questions regarding the origins of the universe, life, and mind were often presented and explored, but the lack of a firm empirical grounding in the knowledge and theory of many subjects (e.g.: human evolution, abiogenesis, star and galaxy formation, cosmology), prevented the coherence of any testable scientific framework or model. Thus, the early study of big history, as well as the formulation of cosmic evolution, failed to mature or gain widespread academic credibility in the 19th century (Dick 2009b). However, in the early 20th century, there were a few works that can be seen as important pre-cursors to the contemporary subject (e.g., Wells 1920; Shapley 1930).

Modern big history is far more comprehensive and active than it has ever been. Big history has played an important role in the philosophy and narrative presented in the massively popular *Cosmos* television franchise (1980; 2014), and is currently becoming an integral part of standardized scientific education at all levels of study through efforts like *The Big History Project*. This more recent incarnation emerged during the last quarter of the 20th century, after the discovery of the Big Bang in 1964. The discovery of the Big Bang allowed for a real beginning to a cosmological story, as well as an empirical way to understand the connections between the worlds of cosmology, physics, and astronomy, and the worlds of chemistry, geology, biology, anthropology, sociology, psychology, cybernetics, and history (Dick 2009b; Spier 2011) (e.g., McGill 1972; Sagan 1977; Cloud 1978; Jantsch 1980; Chaisson 1981; Poundstone 1985; Reeves 1985; Christian 1991). In this historical intellectual environment astronomer Carl Sagan’s introduction of “The Cosmic Calendar” (1977, p. 8) marks an important symbolic moment; as this metaphor captured a clear pattern marked with a directional and accelerating connection from 'particles to people'.

However, big history has a much more complicated history than the one I have constructed. Over the past 200 years the discovery of natural selection, an expanding universe, origins of chemistry and life, origins of the human species and civilization, the chemical composition of the universe, genetics, a detailed understanding of the past and present biosphere, as well as several theoretical advances, have all played an important role in allowing big history to exist as a respectable field of study. Now it seems as though discoveries in every field of academic inquiry play an important role in the big historian's function of identifying macroscopic underlying trends, processes, and patterns of local complexity and order (e.g., Spier 1996; Aunger 2007b), as well as constructing a holistic and unifying narratives of universe, life, and mind (e.g., Sagan 1977; Christian 2004).

When studying the whole of Nature, the current conceptual framework places an emphasis on:

- **Energy:** a necessary component of physical change and structural complexity (e.g., Niele 2005; Spier 2005; Chaisson 2011a, 2011b)
- **Information:** the principal source of functional variation and organizing complexity (e.g., Smith & Szathmáry 1995; Stewart 2000; Corning 2002, 2005; Lloyd 2006)
- **Complexity:** the interaction of functional parts (i.e., agents) within a dynamic, hierarchical, self-organizing, and structural whole (i.e., system) (e.g., Heylighen 2000; Davies 2013)

Also, when studying the whole of Evolution, we must emphasize three major processes:

- **Integration:** the process of subsystems becoming synergistically interconnected into a higher metasystem (Turchin 1977; Smith & Szathmáry 1995)
- **Variation:** the process of subsystem differentiation within larger metasystems (Heylighen 2000; Stewart 2000, 2014)
- **Compression:** the process of metasystems emerging more locally in space (from energy density) and accelerating in time (from information processing) (Smart 2009)

2.1. Three Eras

The universe has been categorized into major eras both "locally" and "globally". Cosmologists developed a universal categorization tool for classifying "global" eras of the physical universe (Table 1), whereas big historians have developed a classification scheme for "local" eras of the physical universe (Table 2). Both categorization tools are based around the concepts and perceived relationships between order/disorder and complexity/simplicity. But of course, it is possible that future investigations will force us to reconsider these categorization schemes.

The global classification of the universe is composed of five major temporal eras based on known (as well as by projected) thermodynamically defined matter-energy regimes. These eras include the Primordial, Stelliferous, Degenerate, Black Hole, and Dark Eras respectively (Adams & Laughlin 1999) (Table 1). All of these eras can be seen as the product of the quantity and inherent physical relationship between gravitationally attractive and repulsive forces (Davies 2013).

Table 1: Five Eras of the Global Physical Universe

Primordial Era	Big Bang (0) – 1 million years A.B. (10^5)
Stelliferous Era	1 million A.B. (10^6) – 100 trillion A.B. (10^{14})
Degenerate Era*	100 trillion A.B. (10^{15}) – Duodecillion (10^{39})
Black Hole Era*	Duodecillion (10^{40}) – Googol (10^{100})
Dark Era*	Googol (10^{101}) and beyond

* = Projected/predicted based on physical shape, matter-energy composition, as well as the current expansion rate.

As the universe is approximately 13.772+/-0.059 Gyr (Bennett et al. 2012), the human species currently finds itself in the Stelliferous Era (Adams & Laughlin 1999). This era is characterized as the only temporal region to play host to star formation (Laughlin et al. 1997), and may therefore be the only era inhabited by complex information processing entities (Linde 1988; Krauss & Starkman 2000; Cirkovic 2004), at least as we know them (see: Adams & Laughlin 1999).

However, there is by no means universal consensus on the potential of habitable zones post-Stelliferous Era (see: Cirkovic 2003), and so we still don't know whether life will remain confined to worlds with stars. But if life is denied any habitable zone post-Stelliferous Era, and is thus pushed to extinction at the end of star formation, there is still a large expanse of time remaining for complex life to emerge and grow (Vidal 2014b). Several trillions of years remain for the universe to produce the structure of complexity found on Earth. Consequently, there are also trillions of years remaining for the future of evolution stemming from our own information processing and replication regime (see: Bostrom 2003; Armstrong & Sandberg 2013). "There are billions upon billions of living places yet to be inhabited" (Wheeler 1988, p. 4).

In contrast to the cosmologist, the big historian attempts to understand the "local" universe, which has existed in three temporal phases based primarily on the density, flow, and ordered/organizing properties of energy (Aunger 2007a; Chaisson 2009a) (Table 2). The first phase is called the "Physical Era" and is characterized by the emergence of inanimate and gravitationally ordered matter-energy (Christian 2004; Spier 2011). During the Physical Era structure in the universe was ordered from the gradual accumulation of unequally distributed matter and dark matter via gravitational attraction (Massey et al. 2007). Therefore, all structure produced during the Physical Era – galaxies, stars, planets – can be attributed to a relatively abundant and natural source of negentropy or "gravitational energy" (Dyson 1971; Corning 2002). Gravitational energy continues to dominate the universe, providing the structural foundation for a grand and uniform "cosmic web": a universe-encompassing platform for more energy dense hierarchical processes (Massey et al., 2007; van de Weygaert & Schaap 2009).

Table 2: Three Eras of the Local Physical Universe

Physical Era	~13.8 billion years B.P. – ~4.0 billion years B.P.
Biological Era	~4.0 billion years B.P. - ~2 million years B.P.
Cultural Era	~2 million years B.P. – Present

The local matter-energy phases of big history occur in three major era based around new means of forming structures and transmitting information.

The second phase of big history can be seen to commence with an important transition from passively ordered structural complexity towards actively organized functional and purposeful living systems

(Thompson 2007; Deacon 2011). Biochemists call this transition "abiogenesis", or the process whereby chemical systems managed to generate living "biological" properties like growth and reproduction (Pross & Pascal 2013). To maintain these properties, living systems are fundamentally distinct from physical systems in their ability to control available energy and distribute and direct it towards processes necessary for their own continued presence (Corning 2002, 2007). Therefore, the transition from physical to living systems is a shift towards systems with information processing and information reproduction (inheritance) capabilities (Aunger 2007b). The hallmark of this system ability is autonomous replication (Pross 2004). Once these replicating chemical systems achieved a dynamic stability with their environment (i.e., persistence) (see: Pross & Pascal 2013), we entered the world of evolving functionality (content and meaning) (Corning 2002).

The functional behaviour of living systems seems to be produced in some way by the process of cybernetic feedback between organism and environment, or subject and object (i.e., input/output) (Corning 2005). This means that all living systems must be dynamically embedded in their environment, allowing them to define functional survival and reproduction goals, as well as overcome challenges in relationship with their socio-ecological circumstances (Heylighen 2012a). As a result, all living systems define, either chemically or symbolically, boundaries between internal organization and the environment. "The split world" (Brown 1967, p. 154). These boundaries serve the dual function of protecting achieved internal organization as well as enabling further growth and learning (Heylighen 2012a), the latter of which is bounded only by finite available energy (Kaplan & Gangestad 2005). Therefore, the entire life history of living systems can be defined by this process of controlling available energy via feedback and directing it towards biological or cultural survival, growth, and reproduction goals (Kaplan & Gangestad 2005; Last 2014a).

The third phase of big history can generally be defined by the emergence of conceptual awareness, as well as conscious awareness of other minds (i.e., groups of organisms with a "theory of mind"). Although many species today display forms of perceptual awareness (Logan 2007; Bermúdez 2009), it seems likely that humans are the only modern species with a comprehensive conceptual understanding of self and existence (Heyes 1998; Call & Tomasello 2008; Penn et al., 2008). This can be perhaps most saliently recognized in analyzing the human/non-human difference in the conceptualization of death (e.g., Teleki 1973; Nakamichi et al. 1996; Hosaka et al. 2000; Warren & Williamson 2004; Anderson 2010; Biro et al. 2010). The human mind is the only known type of mind with the reflexive capability to understand its own finite existence – both our gift and our curse (see: Cave 2012). "Being-toward-death" is our "way of being" (Heidegger 1962, p. 247).

The origin of the human mind is likely an origin deeply intertwined with the origin and structural order of the human symbol system: the linguistic code (Dunbar 2009). The animal kingdom is full of phylogenetically diverse organisms that display complex social learning capabilities and express simple cultural behaviours (Laland & Hoppitt 2003). Notable examples include chimpanzees (Whiten et al. 1999; Boesch 2003), bonobos (Hohmann & Fruth 2003), gorillas (Breuer et al., 2005), orangutans (van Schaik et al. 2003), capuchin monkeys (Fragaszy et al. 2004; Ottoni & Izar 2008), whales (Garland et al. 2011; Rendell et al. 2012), dolphins (Patterson & Mann 2011; Mann et al. 2012), various species of bird (Freeberg 1998; Hunt & Gray 2003; West et al. 2003; Williams et al. 2013), along with several other mammals, and even fish (see: Freeberg 2000; Laland & Hoppit 2003). But humans alone possess a grammatically structured symbol system with the capability of generating the reflective and conceptual narrative structure of mind, as well as complex and adaptive cultural behaviours and artifacts with an independent evolutionary trajectory (see: Marks 2002). Therefore, language enabled both a theory of mind (Dunbar 2009), as well as ratcheting "cumulative culture" (Tennie et al. 2009; Tomasello & Herrmann 2010).

Like all information technologies, human language emerged in response to information overload (Logan 2007). This knowledge combined with our understanding of the primatological correlation between primate neocortex size and group size (Aiello & Dunbar 1993), allows us to construct testable models of language evolution throughout hominid evolution (Dunbar 2003). Current theory and data suggests that modern human language emerged gradually from a form of social grooming in 3 "waves": 2.6-1.6 Mya, 1.5-0.4 Mya, and 300-25 kya (see: Gamble et al. 2011). The modern properties of human language suggest that it originally functioned as a social bonding mechanism (i.e., "gossip hypothesis") in several early members of the genus *Homo*, and then became exapted as a mechanism for the maintenance and improvement of technical complexity (Dunbar 2009; Gamble et al. 2011). However, the exact temporal emergence of important aspects of human language, like storytelling or mythmaking, may forever remain shrouded in mystery (Marks 2012).

Throughout the Physical, Biological, and Cultural Eras of big history complexity has consistently increased progressively with the arrow of time (e.g., galaxies, stars, planets, life, brains, civilization). The complexification process appears to be produced by a relationship between higher information processing capabilities, and higher, denser flows of energy control. In recent years, this local trend towards higher complexity has been quantified with the Energy Rate Density (ERD) metric (e.g., Chaisson 2001, 2011a, 2011b). ERD can be defined by the density of energy flow (erg) through non-equilibrium systems, controlled for both time (s^{-1}) and mass (g^{-1}) (Vidal 2010; Spier 2011). This quantification has demonstrated the often-proposed hypothesis that energy has played some fundamental role in the evolution of higher structure and complexity (e.g., Lamarck 1809; Boltzmann 1886; Spencer 1896; Lotka 1922; Schrödinger 1944; White 1949; Morowitz 1968; Dyson 1971; Prigogine et al. 1972a, 1972b; Smil 1994; Spier 1996).

However, this is not to say that energy dictates living system order/organization (see: Corning 2002). Energy plays a fundamental role in natural structure, but the nature of information and how organisms use information is of equal importance (see: Corning 2007), if not greater importance (see: Smart 2009; Gershenson 2012). The problem is that there is no practically useful method for quantifying information processing, or complexity more generally (Lineweaver et al. 2013b). The originally formulated theory of information – Shannon Information theory – suggests that one can quantify information processing by measuring messages between senders and receivers (see: Shannon 1948; Shannon & Weaver 1949). However, the obvious problem with this measure is that quantifying messages completely ignores the contextual and meaning-laden nature of functional biological and biocultural communication (Kauffman 2000; Logan 2014). Consequently, in reality there is no correlation between Shannon Information and physical order (i.e., negentropy) (Corning 2007).

The subjective nature of information control has led some to assert that an objective and universal measure of information will prove elusive (Maturana & Varela 1980; Heylighen & Joslyn 2001), and will certainly not be found in a reductive framework (Morin 2007). However, there have been attempts to measure biotic information in a non-reductive framework (e.g., Corning 2007; Kauffman et al. 2007; Gershenson 2012; Fernàndez et al. 2013), although many still view ERD as the most useful general complexity metric over the course of cosmic evolution (for more information about ERD see: Chaisson 2001).

2.2 Three Evolutionary Processes

Cosmic evolutionary theory unifies the narrative of big history by utilizing the idea of "evolution" in a hyper-generalized way (e.g., Peacock 2000; Bloom 2009; Dick 2009a; Spier 2011). Evolution in cosmic evolution refers generally to change over time in any physical system in the universe (Chaisson 2009b). The change could be developmental, generational, or in real-time, as well as physical, biological, or cultural (Smart 2009) with selection "targets" in biological and cultural evolution operating at multiple levels of organization (Corning 2005; Burtsev & Turchin 2006), from genes to superorganisms (Hölldobler & Wilson 2008; Stewart 2014). The only real constraint placed on evolution in this context is that it must be applied to open and non-equilibrium systems (Chaisson 2011a). This means that evolution is a concept applicable to all systems that interact with an environment and possess ordered or organized properties. In this sense, cosmic evolution offers a theoretical framework that can unify all sciences (Chaisson 2003; 2013) and piece together the cosmic evolutionary connections from particles to people (Sagan 1973; Dick 2009b).

Throughout cosmic evolution, physical, biological, and cultural evolution has emerged in a directional process with the arrow of time (Chaisson 2009a). The first evolution was a developmental gravitational process that allowed subatomic particles like quarks to bond as the universe first began its expansion (Bloom 2000, 2009). As the universe continued to expand, it cooled, and the force of gravity became a universal material attractor creating levels of structural order in a hierarchical fashion (Springel et al. 2005). Subatomic particles formed baryons, which captured electrons to form the first hydrogen, helium, and lithium atoms (Trefil 2013). These simple atoms formed within the structural edifice of dark matter, allowing for the formation of vast gas clouds (i.e., proto-galaxies) (Loeb & Furlanetto 2013). Further intensification of this gravitational process led to the generation of the first stars, which provided the densities and temperatures necessary for the generation of more complex chemicals like carbon, nitrogen, and oxygen (Impey 2007).

The emergence of the first stars ignited a new evolutionary mechanism: physical evolution based on developmental *and* generational changes (Table 3). The first generation stars were different than second and third generation stars, not only because of the continued expansion of space, but also because second and third generation stars had more diverse chemical materials for the construction of solar systems (i.e., stars with rocky and gaseous planetary bodies) (Impey 2007). Solar systems represent a new type of order in the universe due to both the increased diversity of chemical arrangements and also the new ordered forms that provide a platform for further evolutionary processes (Spier 2011).

The most complex structural entities constructed by physical evolution – stars and planets – go through both developmental and generational changes based on gravitational attraction and chemical variation (Chaisson 2009a). However, with the advent of biological evolution we see the emergence of a new type of evolution, which encompasses developmental and generational change, but also generational selection (Corning 2002) (Table 3). Individual biological entities change in time (development), they change as they replicate (generational), but the success of the next generation in terms of survival and reproduction is naturally selected by socioecological environmental factors (Gould 2002). As a result, biological evolution operates on the fundamental basis of chemical variation and the selection of that variation in relation to environmental conditions (Ruse & Travis 2009). A population of replicating chemicals must sustain their own metabolic activity, but due to scarcity of available energy, there will also be variation in how well individuals within a population of chemicals can achieve this end (Kaplan & Gangestad 2005). Selection then acts as a computation-like information processor building specified functional complexity for work related to energy protection, acquisition, and distribution (Corning 2002); but also for further learning and growing (Heylighen 2014a).

Throughout biological evolution a remarkable degree of complex biological organization has emerged (Smith & Szathmáry 1995; Stewart 2014). This complexity is the result of billions of years of replicating chemical competition and cooperation structured within genetic codes (Corning 2005). Although selection itself is notoriously non-directional (see: Gould 1996), the benefits of synergistic cooperative behaviour can be selected in certain environments (i.e., cooperation can outcompete competition) at all levels of biological organization (see: Corning 2005). As a result, the evolutionary process as a whole tends to build and stabilize higher structural complexity over time, even though selection itself is not biased in any particular simplicity/complexity direction (Stewart 2014). Biological organizations accomplish higher structural complexity with the selection for bio-energetic information technologies that increase their ability to efficiently capture and distribute energy (Corning 2002). Several theorists have identified that the major transitions in the evolutionary process (e.g., abiogenesis, eukaryotes, multicellularity, etc.) can be correlated with significant advances in the functional ability to process and reproduce information (see: Smith & Szathmáry 1995), and the higher structural capabilities to regulate energy flows (see: Niele 2005). These innovations enable the emergence of biological organizations that drift further away from thermodynamic equilibrium (Aunger 2007a; 2007b), with the use of sophisticated information-based controls on organization (Turchin 1977; Corning 2002, 2007).

Throughout the great majority of Earth history biological evolution alone organized matter-energy into new functions and structures. This changed with the rise of the genus *Homo* ~2 million years ago, as early humans acquired the unique ability to engage in the cultural evolutionary process (Richerson & Boyd 2008). Unlike biological evolution, which operates on the generational selection of functional chemical information structured by the genome, cultural evolution operates on the real-time selection of functional symbolic information structured by language (Deacon 1997; Marks 2002) (Table 3). As a consequence, biological structures like genes, chromosomes, and genomes – as well as cultural structures like ideas, theories, and worldviews – are subject to evolutionary selection pressures in humans. This functional symbolic information can produce both adaptive behaviours and adaptive technology (Caldwell & Millen 2008). Therefore, culture is code for inner conceptual experience, outward conceptual behaviour, as well as code for technological structures; in the same way that chemicals code for inner perceptual experience, outward perceptual behaviours, as well as code for biological structures. As a result, organisms subject to cultural evolution are not just in competition and cooperation for energy based on perceptual sensory knowledge of the universe, but also conceptual abstract knowledge of the universe (Logan 2007). In modern human civilization virtually all adaptive complexity is cultural, as opposed to biological (i.e., for human civilization energy control and distribution primarily depends on cultural selection, not biological selection) (Last 2014a).

Table 3: Three Evolutions

Physical Evolution	▪ Developmental ▪ Generational
Biological Evolution	• Developmental • Generational • Selection (Generational)
Cultural Evolution	• Developmental • Generational • Selection (Generational) • Selection (Real-time)

The big history of the universe has seen the emergence of three evolutionary change mechanisms. Each mechanism accelerates the speed of the evolutionary process, allowing for the emergence of ever-more complex structures in ever-shorter periods of time.

Cultural evolution vastly accelerates the speed of the evolutionary process because cultural beings can "save" socioecological and subjective knowledge acquired in real-time, as well as store and transmit information learned in real-time faithfully across many generations (Tomasello et al. 1993; Laland 2008) (Table 3). Like selection for chemical information in biological evolution, selection for symbolic information has no inherent direction within individual cultural beings. Instead, change is always flexibly produced in relationship to socio-ecologies (or socio-economies). However, selection for more complex cultural information (experiential, behavioural, and technical) can collectively take a progressive directional quality within a cultural society. This will be dependent almost entirely on the behaviour of societal controls (e.g., governing institutions) and the technical medium utilized for the storage and transmission of the linguistic code (e.g., writing, printing press, telecommunications, internet) (Last 2014b). As a general principle, the more faithfully a society can store and transmit cultural information between cultural beings and across cultural generations, the less functional cultural information is lost (i.e. "backward slippage"), and the easier it becomes for any given cultural collective to build upon the complexity of inherited cultural knowledge (i.e., "ratcheting") (Tennie et al. 2009). In this sense, the speed of cultural change is a rough function of the qualitative efficiency and quantitative number of conversations (i.e., idea sharing/sex) being conducted within and between individuals and populations (Ridley 2010).

From a cosmic evolutionary perspective, the primary difference between biological and cultural evolution fundamentally remains in the reproduction capability and pathway (see: Last 2014a). Biological evolution is a mature and independent process that does not require culture to exist. In contrast, cultural evolution is still very much a young and dependent process that does require biology to exist. This of course makes all of human evolution biocultural, and not simply biological or cultural (Marks 2013). There are no cultural beings that come into existence and remain in existence without the aid of a biological substrate. Consequently, all cultural beings are the ultimate products of biological reproduction and a chemical genetic code, as opposed to the ultimate product of cultural reproduction and a symbolic linguistic code (Last 2014a)

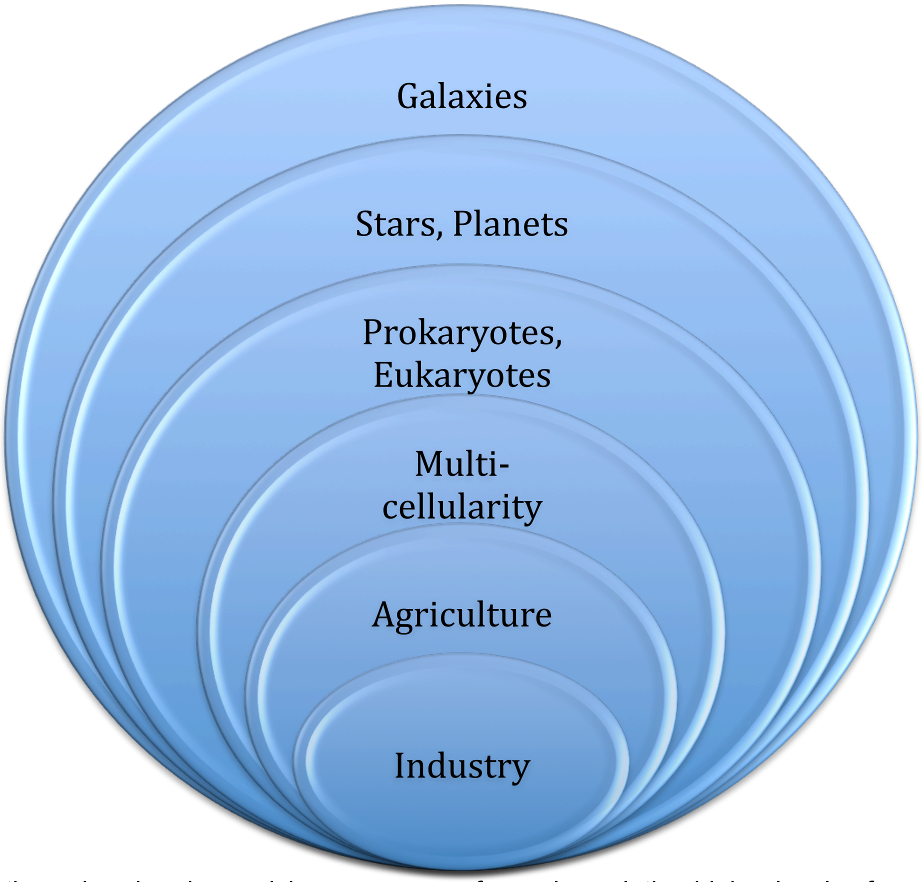
However, when we look back over the scales of 13.8 billion years of evolution, we can see that the complexity of matter-energy organizations has consistently increased. In the same way that big historians are beginning to identify important trends related to complexity throughout the Eras of cosmic history, cosmic evolutionary theorists must identify key trends and properties of cosmic evolution itself. Identifying large-scale trends throughout the whole of cosmic evolution increases our ability to build predictive models regarding the potential future properties of the evolutionary process. As of now there are three potential candidates for trends in cosmic evolution that appear to manifest as complexity increases. The first trend is increased cooperative *integration* of "parts" into "wholes". Throughout physical, biological, and cultural evolution we have seen the emergence of larger and more dynamic metasystems composed of smaller subsystems (Turchin 1977; Smith & Szathmáry 1995; Heylighen 2000). In some sense this is intuitively obvious as atoms developed into molecules, molecules developed into simple organisms, simple organisms developed into more complex multi-cellular organisms, and multi-cellular organisms developed societies of multi-cellular organisms.

The second trend is related to increased *variation* (also referred to as diversification, specialization, or novelty) of subsystems within metasystems (McKenna 1998a; Heylighen 2000; Stewart 2014). This trend simply recognizes that there are increasing symbiotic differences between subsystems as cooperative integration progresses to higher-levels of metasystem order/organization (Turchin 1977; Stewart 2000, 2014). For example, subsystem variation increased progressively with the emergence of galaxies, stars, planets, prokaryotes, multi-cellular organisms, multi-cellular organism societies, and now the various cultures and technologies produced by human civilization. Variation and integration of that variation within larger wholes accurately captures the first two dominant trends in cosmic evolution.

The third candidate trend in cosmic evolution has had a complex history, but we will call it: compression (also referred to as STEM (space-time-energy-matter) compression) (Smart 2009). Compression suggests that complex metasystems are developmentally and hierarchically constrained to emerge more locally in space than previous systems, as well as to accelerate change in time. Spatial localization presumably arises from increased density of energy flows, and temporal acceleration appears to arise from increases in information processing capabilities. Historically related concepts have mostly been used to describe accelerating physical change with time (e.g., Adams 1909; Teilhard de Chardin 1955; McKenna 1998a; Smart 2000; Kurzweil 2005). But space and time are connected dimensions, and so it may be best to conceptualize temporal acceleration and spatial localization as coupled processes related to increases in evolutionary complexity (i.e., integration and variation).

For example, galaxies represent structures of low complexity, but they have existed for longer periods of time than stars, planets, or life, and they also occupy larger expanses of space than stars, planets, or life. In contrast, industrial civilization represents the frontier of complexity in the known universe, but industrial civilization exists on the smallest scales of both space and time. This is to say that industrial civilizations are hyper-localized spatially in urban organizations, and hyper-localized temporally, having only existed for 250-300 years. Throughout the whole of cosmic evolution structures have been emerging in increasingly local domains of both space and time (see: Smart 2009, 2012) (Fig. 1.). If this process were to continue – space-time would be abolished – and our entire awareness a singularity. The dimensional walls are closing in.

Figure 1. Evolutionary Compression: Hierarchical and Developmentally Constrained Universe



Throughout the ordered and organizing processes of cosmic evolution higher levels of complexity have emerged in physical, biological, and cultural systems. Apart from emerging in a directional dimension with the arrow of time, these phenomena have also emerged in ever more local regions of space-time. This is achieved by utilizing ever-denser forms of matter-energy. Therefore, complexity in our universe may follow a developmentally constrained localization property that can be roughly correlated to major energy transitions away from thermodynamic equilibrium. For example, stars developed more locally within galaxies; planets developed more locally within solar systems; life developed more locally on planets; multicellularity developed more locally than prokaryotes and eukaryotes from simpler life; agricultural civilization developed more locally from multicellular life; and finally industrial civilization developed more locally from agricultural civilization. In the modern world we see an overwhelming demographic shift from rural-to-urban, suggesting that by 2050 the large majority of humanity will be congregated hyper-locally in vast mega-cities, which are also the localized hubs for further localization, currently emerging in the form of advanced super-computation.

From our analysis of the big historical eras and cosmic evolution we have identified important trends that appear to have been generated from "Big Bang to Global Civilization". Throughout the big historical eras complexity has increased, and we have stared to gain an understanding of this complexity increase in measurable terms related to the density of energy flow (Chaisson 2011a; 2011b). But equally important, we have seen that as complexity increases, so has the ability to control energy flow with increasingly sophisticated information processing mechanisms (Corning 2002). These physical processes have driven cosmic evolution enabling increased integration, variation, and compression of metasystems. These deep and potentially unifying trends of both big history and cosmic evolution may allow us to make specific predictions about the deep future of human civilization and cultural evolution. Will higher energy flows and information processing technologies allow for maximum integration, variation, and compression? What would be the Nature of such an entity?

When thinking about these issues we will have to push the very limits of scientific knowledge and understanding. But first we should review what we do know about the future of the Physical and Biological Eras.

2.3 The End of Order?

The three eras and evolutionary processes of big history help us to organize and understand vast periods of time that connect seemingly unrelated phenomena into one interrelated process contextualizing the existence of modern humans in the 21st century. However, big history rarely confronts the potential implications of big historical knowledge for our own future as a species. What can the overall trends and patterns of cosmic evolution tell us about the deep future of humanity?

The future big histories of the Physical and Biological Eras are, to some extent, well known (or at least easily extrapolated). Of course, Earth's biological complexity is dependent on local physical complexity, and so the Biological Era's future is intricately dependent on the future of our own solar system. Our star, the Sun, is approximately 4.5 billion years old (Connelly et al. 2012), and is in the middle of a 10 billion year "main-sequence" phase characterized by hydrogen fusion (Beech 2008). However, over the course of the main sequence phase the Sun's luminosity and radius will gradually increase on geologic and astronomical timescales as the Sun runs out of hydrogen reserves (Ribas 2009). This process will result in Earth developing a Venus-like atmosphere in ~3 billion years (Franck et al. 2005).

In this hypothesized future, biological life has a gloomy ultimate fate. Throughout the evolution of life history there have been major transitions towards increased complexity with the emergence of prokaryotes, eukaryotes, and multicellular eukaryotes (i.e., plants, animals, fungi) (Smith & Szathmáry 1995; Stewart 2014). These forms of life evolved in a directional order: prokaryotes (3.5 Gyr) (Bada & Lazcano 2009), eukaryotes (2.0 Gyr) (Tomitani et al. 2006), multicellular eukaroytes (1-0.5 Gyr) (Knoll et al. 2006; Grosberg & Strathmann 2007). Current models suggest that, as our Sun's luminosity and radius increase, increased energy inputs will disrupt Earth's carbon cycle, causing several intensive, successive, and irreversible disturbances in complex life's ability to survive (Ribas 2009; O'Malley-James et al. 2013). This is hypothesized to cause the extinction of major forms of life in reverse chronological order to their original appearance: multicellular eukaryotes (0.8 Gyr), eukaryotes (1.3 Gyr), prokaryotes (1.6 Gyr) (Franck et al. 2005). Therefore, Earth will possess an atmosphere with astrobiological "Earth-like" qualities for a relatively brief period of its overall existence (~2 billion years) (Brownlee 2010). However, depending on prokaryotic adaptive resilience (which seems to be quite high), these simple life forms could exist as many as 2.8 billion years into Earth future (O'Malley-James et al. 2013).

The future of the Physical Era proves to be equally gloomy. In our local universe the Sun will eventually enter its red giant phase characterized by helium fusion (Beech 2008). Current estimates suggest that this could occur around 5-8 billion years from the present (Boothroyd & Juliana-Sackmann 1999; Schröder & Smith 2007). In its red giant phase, the Sun will swell in diameter to ~2 astronomical units (AU), eventually consuming Mercury, Venus, and most likely Earth, in the process (Rybicki & Denis 2001; Schröder & Smith 2007). However, the Sun will not explode as a supernova but instead enter a short 10 thousand year phase as a planetary nebula, ejecting ionized gas into its surrounding spatial medium (Bloecker 1995). After this phase, the Sun will then settle into a cool white dwarf phase, which could survive for trillions of years before eventually burning out entirely (Bloecker 1995; Veras 2014).

During the Sun's stellar development, our solar system will be undergoing a larger galactic transformation. Currently our system exists within the Milky Way galaxy: a barred spiral galaxy composed of 200-400 billion stars (Gerhard 2002), at least 200-400 billion planets (Cassan et al. 2012), and a ~100-120 thousand light year diameter (Gerhard 2002). However, in ~4 billion years the Milky Way will collide with its closest neighbouring galaxy, Andromeda, producing "Milkomeda" an elliptical galaxy composed of ~1 trillion stars (Cox & Loeb 2007; Cowen 2012; Goldsmith 2012). Throughout the Milky Way-Andromeda collision our solar system should remain undisturbed. However, the collision will significantly affect our system's position vis-à-vis the galactic core (Cox & Loeb 2007).

In the deeper future of the Stelliferous Era (i.e., 1-10 trillion years) most or all-galactic structures in Laniakea, our home supercluster of galaxies (see: Brent Tulley et al. 2014; Gibney 2014) will eventually merge with Milkomeda as an even larger elliptical galaxy (Adams & Laughlin 1997). During this time all galaxies external to the Local Group will recede from our local universe's horizon (Loeb 2011). Towards the end of the Stelliferous Era and the beginnings of the Degenerate Era (Table 1) only planets, white dwarfs, and neutron stars will remain (Adams & Laughlin 1997). This will likely mark the end of life, and the beginning of the universe's practically infinite descent into thermodynamic equilibrium (Adams & Laughlin 1999). Although, it must be noted that this future for physical evolution is dependent on the nature of the dark universe (i.e., dark matter and energy): two very important *somethings* comprising 95.1% of our universe (Ade et al. 2013), but whose nature(s) remain largely mysterious (see: Livio 2010). The range of speculation on the nature of dark matter and energy is beyond the scope of this paper, however I think it is safe to say that a deeper understanding of these currently missing components of the cosmic picture will affect our understanding of the deep future of the physical universe.

Extrapolating our current understanding of the universe leaves little room for optimism. A future with no structure or available energy is a future with no complexity, no information processing and replication, no humanity, and no mind. This has had a profoundly negative and very real psychological affect on the consciousness of the scientific mind, and particularly the Western scientific mind. Our vision has been trapped by the abstract concept of entropy. We cannot imagine a hope in the enterprise of life, as perhaps best captured by philosopher and mathematician Bertrand Russell (1903, p. 7):

> "All the labours of the ages, all the devotion, all the inspiration, all the noonday brightness of human genius, are destined to extinction… The whole temple of Man's achievement must inevitably be buried beneath the debris of a universe in ruins."

But we often discuss the deep future as if life and intelligence will not be an *active* part of it: thought as shaping and directing the future (e.g., Wheeler 1988). After all: "life and intelligence are the wildcards in the universal deck." (McKenna 1994b). Therefore, when we discuss the deep future of big history, the most recent emergent Era of human awareness, and the most recent emergent Evolution of cultural evolution, must be *seriously* contemplated as playing a fundamental role. Cultural evolution is still increasing complexity in the universe via the development of more advanced information technologies, and the regulation of denser energy flows. Cultural evolution is also still capable of engaging in the three major trends of evolution: integration, variation, and compression.

Therefore, if we are going to find optimism in the deep future, we can say that cultural evolution presents us with a process that gives the appearance of the "leading edge" of higher complexity. However, despite detailed knowledge of the future biosphere and solar system, we have a remarkably poor understanding of the deep future potential of culture as both a creative process and as an evolutionary mechanism to change the future nature of both biological and physical evolution (see: Vidal 2014b). The way forward is clear: we must develop an understanding of the nature and potential future of the cultural evolutionary pathway, what is being termed "cosmic culture" (see: Dick & Lupisella 2009). Understanding cosmic culture could offer us an alternative glimpse of the future of universe, life, and mind. "One of the main purposes of science is to investigate the future evolution of life in the universe." (Linde 1988, p. 29).

3. Human Future

The human future has been a source of tremendous scientific interest since the Scientific Revolution. Philosopher Francis Bacon – a pre-eminent figure of the Scientific Revolution – realized that the nature of science could radically alter the human future, potentially bringing about "things which have never been achieved" and alter being in ways that "were unlikely ever to enter men's minds." (Bacon 1620, p. 103). Bacon and his contemporaries had essentially uncovered the fact that human imagination combined with a rigorous experimental methodology could allow for what we may refer to as a "maximum possibility space" (Bacon 1626, p. 19):

> "The end of our foundation is the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human empire, to the effecting of all things possible."

However, the real flourishing of a scientific futurism could not occur until Darwinian theory introduced a framework for thinking about change over time (e.g., Darwin 1859). Charles Darwin himself used an evolutionary framework to speculate that the human future may still hold surprises and unrealized potential, although he did not speculate further (Darwin 1871, p. 492):

> "Man may be excused for feeling some pride at having risen, though not through his own exertions, to the very summit of the organic scale; and the fact of his having thus risen, instead of having been aboriginally placed there, may give him hope for a still higher destiny in the distant future."

Following Darwin's speculation there was a relative explosion of sophisticated philosophical thought regarding the future evolution of humanity (e.g., Nietzsche 1883; Astor 1894; Spencer 1896; Adams 1909; Tsiolkovsky 1911; Wells 1920; Haldane 1924). Since the introduction of evolutionary theory several academics have suggested that Darwin's "higher destiny in the distant future" would manifest in the form of an "intelligence explosion" produced from the accelerated evolution of human communication and information technologies (ICT) (for historical and analytical overviews see: Sandberg 2010; Heylighen 2012b).

All future-oriented intelligence explosion theorists have predicted that a near-term event (on the scale of the next 50-300 years) will shake the very foundations of our understanding of human individuals and civilizations (Goertzel 2002, p. 1-2). Traditionally, and most popularly, the hypothesis of an intelligence explosion has been integrated into the conceptual framework of "technological singularity" (see: Sandberg 2010).

Technological singularity theory posits that the human individual will achieve superintelligence through technological modifications and/or will be replaced by superintelligent technologies (Vinge 1993; Schmidhuber 2012). This paradigm understands the future of human civilization through the perspective of the advancement of artificial intelligence and robotics (see: Kurzweil 2005; Blackford & Broderick 2014), and specifically the emergence of an artificial general intelligence (AGI) (Pennachin & Goertzel 2007).

Technological singularity intelligence explosion scenarios for the future of humanity have been proposed throughout the 20th century from a diverse variety of academics (see: Adams 1909; Ulam 1958; Good 1965; Moravec 1989; Glenn 1989; Vinge 1993). These theories have attracted increased academic attention in recent decades (including the establishment of future-oriented university-based institutions), influenced many recent well-received popular science books (e.g., Kelly 2010; Diamandis & Kotler 2011; Kaku 2014; Bostrom 2014), and have also spawned a philosophy referred to as "transhumanism" (see: Huxley 1968; Bostrom 2005a). However, theorists have rarely attempted to merge the conceptual framework of technological singularity into the larger framework of cosmic evolution (with the notable exception of: Kurzweil 2005), or build these understandings of the human future into the theoretical framework of big history (i.e., what are the implications of technological singularity for the Physical, Biological, and Cultural Eras?).

3.1. Technological Singularity

The technological singularity was an idea originally inspired from the physical sciences, and specifically by pioneering work in computer science and cybernetics (e.g., Shannon 1948; Wiener 1948; Turing 1950). Many researchers quickly realized that the emergence of advanced computation represented an important turning point in the history of technological progress, as cybernetic computing machines could now be designed to solve problems that only humans had been able to solve in the past (see: Wiener 1948, 1950, 1963). The specific term "singularity" was first used to describe a future period of time when human civilization possessed the powerful problem solving computational capabilities that would make obsolete the need for biological human problem solving (e.g., Ulam 1958).

However, the possibility of human-level machine intelligence immediately forces one to confront the possibility of beyond human-level machine intelligence. After all, if humanity was close to designing a machine with human-level problem solving capabilities, was it not possible for *that machine* to either increase its own intelligence by re-programming its source code, or to start programming an even more intelligent machine, which could then program an even more intelligent machine, *ad infinitum*? This idea of the future of machine intelligence as unleashing a strong positive cybernetic feedback loop has most popularly captured the imagination of singularity theorists since its introduction (e.g., Good 1965). In this singularity-based conception of the future, emergence of the first AGI will be followed closely by the emergence of an AI+, and an AI++, and an AI+++, etc. (Chalmers 2010). Therefore, this event would represent a period in big history when the universe moves on to beyond human level information processing and reproduction, and presumably, new domains of subject/object experience unknown to the biocultural human. Transcendence; science becomes religion and idealist philosophy (Zimmerman 2008).

The early era of singularity theory has since been replaced by a modern era grounded in testable predictions related to the advance of ICT, and specifically the advance of computation (see: Vinge 1993; Kurzweil 2005, 2010; Sandberg & Bostrom 2008; Nagy et al. 2011; Loosemore & Goertzel 2012). Singularity theorists have become dependent on the predictive power of "Moore's law" (e.g., Moore 1965, 1975), according to which the speed of microprocessors doubles every ~18 months (see: Schaller 1997). The overwhelmingly consistent accuracy of Moore's law has made the concept of "exponential acceleration" a very useful and powerful tool in forecasting 21st century technological possibility (see: Kurzweil 2001, 2010; Bostrom 2006; Diamandis & Kotler 2011). However, recent analyses of long-term computer trend data suggest that this computational acceleration may in fact be *super*exponential with shrinking doubling times (see: Nagy et al. 2011).

The 21st century ramifications of exponential (or superexponential) growth in computing are indeed overwhelming. For example, the most advanced supercomputers in 2013 could run at 50 petaflops (i.e., a thousand trillion calculations per second). This astoundingly high level of computation has the capacity of simulating only 1 percent of 1 second of human brain activity (Broderick 2014). However, because computational power doubles every year and a half, according to Moore's law, we should expect to possess the capability of completely simulating the entire human brain at sometime between 2030-2050 (Pennachin & Goertzel 2007). It is this specific prediction that has resulted in many researchers believing that the technological singularity will occur before mid-century (see: Vinge 1993; Hanson 2000; Kurzweil 2005). In fact, this date now appears to be in-line with the majority of the artificial intelligence (AI) research community's belief that human-level or beyond human-level AI will be possible before 2050 (see: Klein 2007; Baum et al. 2011), and highly probable before 2100 (see: Baum et al. 2011; Sandberg & Bostrom 2011).

Therefore, if the AI community's technological expectations are met it seems reasonable to suspect a quickly intensifying transition from narrow AI systems that can solve specifically programmed problems towards general AI systems that can solve a multitude of problems (Pennachin & Goertzel 2007). However, a true intelligence explosion would only occur after the emergence of an artificial general intelligence (Loosemore & Goertzel 2012). This means that the first half of the 21st century could be characterized by the emergence of a world in which machines will be able to solve all of the problems that were once the sole domain of the human intellect (for a fantastic visual presentation of this, see: Grey 2014). In fact, many scientific reports and forecasts for the future of work reflect this reality, as the process of outsourcing problems to computation is already under way (see: Frey 2011; Frey & Osborne 2013; Brynjolfsson & McAfee 2014; McGinnis & Pearce 2014; Rifkin 2014), albeit in an early phase.

However, it must be noted that the emergence of AI systems with the ability to solve complex problems is very different from the emergence of human-like general intelligence (Pennachin & Goertzel 2007). And it is entirely possible that advanced problem solving AI systems will emerge, without any emergence of a real machine mind with thoughts and feelings. After all, computers are now the world's best chess players and *Jeopardy!* contestants but they accomplish this without self-awareness, and without any emotion or feeling (Broderick 2014). Therefore, replicating the often over-looked properties of "being" and "meaning" that permeate the existence of living systems, may be entirely unrelated to computation (Kauffman 2010). And thus, predicting the rise of machine life and superintelligence based on Moore's law prove to be naïve.

However, from Moore's law extrapolated data, predictions of the singularity itself have been subject to much speculation. First and foremost: what will be the transition's nature? (Table 4) (For more see: Goertzel 2007; Vinge 2007a; Sandberg 2010):

Table 4: Nature of Technological Singularity

Artificial Intelligence (AI) Scenario	Superintelligent technology replaces biocultural humans
Intelligence Amplification (IA) Scenario	Humans transform themselves with technology and become transhuman/posthuman
Human-Technology Merger (HTM) Scenario	AI and IA scenarios occur simultaneously manifested from evolutionary pressures and positive feedback loops generating biology-technology symbiosis

There is just no way to test the AI, IA, and HTM hypothetical scenarios and therefore, unsurprisingly, there is no general consensus as to which scenario is most probable among singularity theorists (see: Sandberg & Bostrom 2011). However, some theorists have advocated for a moratorium on artificial intelligence research to increase the probability of the IA Scenario (e.g., Antonov 2011), while others have suggested that we actively "delay the singularity" by constructing an "AI Nanny" until we better understand the potential ramifications (e.g., Goertzel 2012). Despite these pleas, most theorists think that – on the whole – the technological singularity will be characterized by some variant of the IA/HTM scenarios, and thus usher in a new era of opportunity and possibility for the exploration of post-human mind and consciousness (Hanson 2000; Bostrom 2005b; Kurzweil 2005; Kaku 2014). Therefore, it is reasoned that we should boldly move forward with research related to equaling and surpassing human intelligence with computers (Kurzweil 2012; Blackford & Broderick 2014; Kaku 2014, with a notable exception, see: Bostrom 2014).

In recent years it appears as though we are moving forward with technical projects that could realize any of the singularity scenarios suggested above. For example, human governments, including the European Commission and the United States of America are funding billion dollar projects related to simulating and modeling the human brain (e.g., Human Brain Project; the BRAIN Initiative) (Broderick 2014). The long-term potential of these "big science" projects could allow researchers to create what has been defined as a whole brain emulation or "em" (Sandberg & Bostrom 2008). Whole brain emulations are hypothesized to result from the construction of complete structural computer models of individual brains (i.e., to map and reproduce the human connectcome, see: Sporns 2012). The creation of whole brain emulations would completely revolutionize human existence, as it could potentially be used to simulate all of the cybernetic input-output functions of a biological human brain (Hanson 2014). As a result, individual humans may have the option of "saving" and/or "transferring" their brain into a technological substrate in the 21st century (Sandberg & Bostrom 2008) (This is of course assuming that mind can be saved and transferred in this way, see: Heylighen 2012c; Corabi & Schneider 2014).

All of this technological singularity theory is situated at the very heart of the largest divide within academia since the time of the Platonic dialogues: What is the human mind? And what is the mind's relationship to the biological brain? Disagreements in this theoretical battle revolve around how material substance produces subject with intentionality, creativity, and awareness (Searle 1990; Dennett 1991; Thompson 2007; Kauffman 2010; Deacon 2011; Kurzweil 2012; Žižek 2012). This problem has profound implications for whether or not humans will be interacting with and/or becoming technological minds this century. In short, will the singularity be characterized by the emergence of very advanced chat bots and knowledge engines, or will the singularity be characterized by the emergence of technological *beings*?

The dominant paradigm in AGI-related research understands the human mind to be the production of symbolic code-related computations (Pennachin & Goertzel 2007). This paradigm suggests that algorithms (i.e., procedures for calculating a result), can explain everything humans do and everything humans are (Kauffman 2010, p. 177). However it must be recognized that the human mind does not just compute symbols to solve problems (Heylighen 2012c). Anyone with a mind knows that mind also attaches meaning to symbols and experiences being through thought (Žižek 2012). Currently, no computational theory of mind can explain how an algorithm could reproduce these properties (Kauffman 2010). The mind is a phenomenon that experiences thought, has wants, and develops goals; and no supercomputer – no matter how powerful – has displayed the slightest signs of exhibiting these properties (Broderick 2014). Computers are problem solving tools, and not creative expressions of thoughtful being. Therefore, the question of how mind fundamentally produces the properties of being and meaning may or may not possess some relation to computation. It could be that these properties have more to do with embodied experience and evolutionary development as a system dynamically embedded within an environment (Heylighen 2012c). But at this point the only certainty we have is that we have a lot more to learn about the possibility of artificial general intelligence and the future of mind (Pennachin & Goertzel 2007).

3.2. Atechnogenesis and Technological Life

As stated above, the technological singularity concept was constructed from theory in the physical sciences, and specifically the mathematical notion of "singularity" where a radical material discontinuity in a physical system results in infinite values (i.e., infinite density in space-time black holes). However, many contemporary futurists and computer scientists are beginning to shy away from the concept of technological singularity (e.g., Dvorsky 2014; Naam 2014). Ramez Naam, a technologist, science fiction writer, and professor of computer science at *Singularity University* explained most succinctly why many academics are breaking away (Dvorsky 2014):

> "'Singularity' in mathematics is a divide-by-zero moment, when the value goes from some finite number to infinity in an eye blink. In physics, it's a breakdown in our mathematical models at a black hole. Smarter-than-human AI would be very cool. It would change our world a lot. I don't think it deserves a word anywhere near as grandiose as 'Singularity'. It wouldn't be a divide-by-zero. The graph wouldn't suddenly go to infinity. Being twice as smart as a human doesn't suddenly mean you make yourself infinitely smart."

In short, a concept rooted in physical and mathematical theory does not work because it cannot explain an event that is inherently evolutionary in its nature. Our civilization does not face a "black hole of intelligence" as the concept of technological singularity suggests, but rather, we face the full emergence of a new evolutionary pathway: the true birth and independence of cultural evolution. As we covered when discussing cosmic evolution, cultural symbols code for inner conceptual experience, outward conceptual behaviour, as well as for technological structures. This can be seen as analogous to the way that chemicals code for inner perceptual experience, outward perceptual behaviour, as well as for biological structures. Consequently, the biocultural human lives in both a perceptual and a conceptual landscape, and the technologies we produce are an integral aspect to the cultural evolutionary process. Within this cosmic evolutionary framework we can take a different approach to understanding the future.

The technological singularity appears to be attempting to describe the emergence of technological life, and in particular, the emergence of technological intelligent life, as stemming from our own accelerating symbolic activities. If our symbolic activities either A) allow us to merge with our technologies and become technological beings, or B) allow us to create self-producing technological life from advances in robotics and artificial intelligence (see: Section 3.1.), this would be a process whereby symbolic code produced technological structures with evolutionary-cybernetic properties analogous to biological living systems. Such systems have been referred to with concepts like "postbiological life" (Dick 2008; 2009a) and "machinic life" (Johnston 2008). Many theorists now assume that technological life represents a natural extension of biological life with the potential to re-shape the cosmos (e.g., Gardner 2005; Kurzweil 2005; Smart 2009; Kelly 2010; Martinez 2014). "I think it is very likely – in fact inevitable – that biological intelligence is only a transitory phenomenon, a fleeting phase in the evolution of intelligence in the universe." (Davies 2010, p. 160).

When contemplating the possible emergence of technological life there is only one analogous known event in cosmic evolution: abiogenesis. Abiogenesis literally means "biology arising from not-biology". After the process of abiogenesis, all life has been produced via biogenesis, or "biological life arising from biological life". As we have already discussed, although cultural evolution is a new evolutionary pathway, it is a pathway that has not gained its own independence. Culture is dependent on biogenesis for its own existence. However, if symbolic systems manage to construct technological systems with biological properties (i.e., technological life), this would no longer be the case. The biocultural being would become a transitionary stage between the worlds of the biochemical and the worlds of the technocultural.

Therefore, in order to properly understand and contextualize the potential rise of a new form of life within a new independent evolutionary process, we need an evolutionary-cybernetic concept. This concept must accept that the phenomena driving this new evolution – culture, technology, language, and mind – have existed for millions of years as part of one continuous process. I think this process is best conceptualized as:

"**Atechnogenesis**" (*AY-tech-oh-JEN-e-siss*): a process in cosmic evolution whereby symbolic cultural information processing and reproduction transcends biochemistry by developing a technological substrate of mind design.

Let me first make a quick comment regarding the concept "atechnogenesis". First, like "abiogenesis", which means "biology arising from not-biology", atechnogenesis refers to a process whereby "technology arises from not-technology". This may sound counter-intuitive at first but the whole of human evolution can be conceptualized as a gradual (yet accelerating) process where symbolically mediated mind was able to conjure technological structures out of "not-technology". Every technology that has ever existed – from an Oldowan hand axe to the most advanced supercomputer – is an organization of atomic systems designed by an aware mind from constituent elements that were previously ordered or organized within a formerly geological, chemical, or biological physical structure. This is to say that the emergence of any technology is a symbolic process where mind creates technological organization out of "not-technology". In Nature, biology is self-produced, or in other words it is "autopoietic"; but technology is not self-produced, yet.

In this paradigm of thinking, atechnogenesis is not an "event", but rather an on-going evolutionary process. Atechnogenesis began when our ancient ancestors started to shape rocks (and presumably other more perishable materials) (i.e., not-technology) into technologies that extended their abilities beyond the domain of biology. The end of atechnogenesis can be thought to conclude when the fundamental mind-driven symbolic activity of transforming the physical environment is being carried out within a technological substrate: mind as transcending biology completely with technology. Therefore, the end of atechnogenesis is the beginning of technogenesis; or "technological life arising from technological life". This analogy is to compare atechnogenesis with abiogenesis, and also to compare biogenesis with technogenesis. Atechnogenesis to technogenesis then potentially allow for an evolutionary re-conceptualization of the future that allows us to model the phenomenon as a process comfortably situated within the ongoing and integrated process of cosmic evolution.

To my knowledge, the concept of "atechnogenesis" is novel. However, the concept of "technogenesis" is not novel. Historically the term "technogenesis" has been mostly used by postmodern academics to describe the co-evolution of humans and technology (e.g., Hayles 2012, p. 10):

> "[C]oncept of technogenesis, the idea that humans and technics have coevolved together."

However, considering the concept "biogenesis" literally means "biological life from biological life", the concept "technogenesis" should probably be interpreted to mean "technological life from technological life". Currently, all technology that exists on our planet would not exist if it were not for the biocultural activities of the human mind. Biocultural activity transforms not-technology into technology. Therefore, all technology that arises on our planet is part of "atechnogenesis". This is for the simple reason that, fundamentally, technology is not self-produced. If the biocultural human disappeared, technology would stop being produced. Even modern technologies produced on automated technological assembly lines are fundamentally conceptualized, established, and maintained by biocultural humans at some point in the process. Technology is not yet completely autopoietic, i.e., self-producing. From this perspective we are not yet in the world of technogenesis. And so, I would also ask for a re-conceptualization of the historical use of the word "technogenesis".

Moving forward, I think this evolutionary framing of technology and biocultural humans will be helpful for thinking about cosmic evolution as a whole and making progress in understanding many different phenomena. For example, the biochemical evolutionary pathway has dominated the evolution of life on earth. This is to say that the history of life is the history of variant chemical structures harvesting energy to create ever more complex replicates of similar forms (Kaplan & Gangestad 2005). The emergence of this pathway – abiogenesis – is still not completely understood, but biochemists are in universal agreement that it was a process in which autocatalytic chemical system(s) achieved independent growth, maintenance, and reproduction (Pross & Pascal 2013). By analogy, atechnogenesis would represent a process (carried out by biocultural humans over millions of years) in which symbolic system(s) eventually achieved growth, maintenance, and reproduction; independent from biological evolution's genetically programmed substrate. Evolution directed solely by aware minds within a technological substrate of mind design. This concept fits with technologist Kevin Kelly's notion that technology is new kingdom of life that has yet to break away from biology (see: Kelly 2010) (i.e., yet to achieve technogenesis).

From the process of abiogenesis, biological evolution has produced three major domains of biological life: archaea, bacteria, and eukarya; all domains classified based on biochemical organelle structures (see: Woese et al. 1990). Archaea and bacteria are prokaryotic, whereas the eukarya are living systems with a nucleus and membrane-bound organelles, which includes most multi-cellular life (Woese et al. 1990). However, humans do not fit neatly within this biological classification scheme because our informational properties are not simply embedded within biochemistry. As we have discussed, the emergence of the genus *Homo* represents the emergence of a new evolutionary pathway, and the emergence of a biochemical lineage of forms that also produce symbolic information. As a result, humans do not simply consist of variant chemical structures harvesting energy to create ever more complex replicates of similar forms, but variant chemical *and* variant symbolic structures. Therefore, the emergence of humanity can *only* be compared to the origin of life itself (Turchin 1977, p. 84), which seems to suggest that the introduction of the concept "atechnogenesis" finds a perfect parallel with the concept of "abiogenesis".

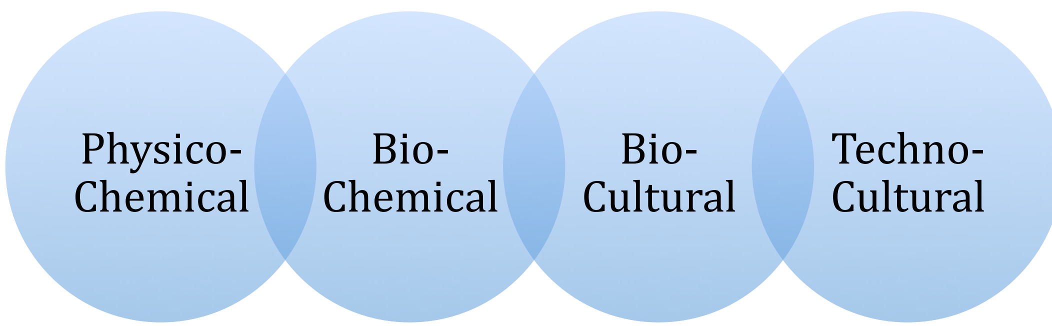
Furthermore, evolutionary scientists have recognized that the cultural evolutionary pathway displays many striking similarities to the biological evolutionary pathway, and that those similarities uniquely manifest in the human species (see: Tomasello et al. 1993; Caldwell & Millen 2008; Laland 2008; Tennie et al., 2009; Last 2014a). However, as stated above, the primary difference between the biological and cultural evolutionary pathways is that the biological pathway is independent, whereas the cultural pathway is entirely dependent on biological reproduction for its continued existence. This is to say that, although biology and culture both possess reproduction capabilities, all living systems are still only ultimately produced via biological reproduction (i.e., biogenesis) and sustained by a biological substrate. As a result, cultural reproduction can only occur within a substrate of an origin that is biological in nature.

But culture is unlikely to remain shackled to biology. Cosmic evolution teaches us that new evolutionary processes have emerged in the past. Today, we already see evidence that biological reproduction is being outcompeted by cultural reproduction (see: Last 2014a). The symbol system of cultural evolution does not have to deal with the same physical constraints of biological evolution, as it is a process that occurs in real-time, produces conceptually-mediated awareness, allows for production of technology, and consequently, allows for the construction of unprecedented cosmic integration, variation, and compression. Therefore, although the technological singularity concept may fail to conceptualize the future of human evolution, the future process it points towards, is of unparalleled importance: the process in which symbol system(s) break free and become independent of biology.

However, if we can conceptualize atechnogenesis and technogenesis as analogous to abiogenesis and biogenesis, we may have a better conceptual frame for many practical, as well as many theoretical reasons. First and foremost, these are concepts that can be used by chemists, biologists, anthropologists, cyberneticists, computer scientists, engineers, historians, and philosophers to organize research around an understanding of the future of human evolution. In contrast to the technological singularity, the term atechnogenesis does not place a heavy emphasis on Moore's law and computational power to explain the emergence of superintelligence and technological life. Instead, the entire point of the concept atechnogenesis is to direct attention towards concepts that interest biochemists, cyberneticists, and systems theorists studying abiogenesis, as well as evolutionary scientists of all backgrounds who study the relationship between biology and technology, or chemistry and culture. After all, if technological life emerges it will be from approaching robotics from an evolutionary-cybernetic perspective.

Finally, the concept atechnogenesis immediately furthers our understanding of cosmic evolution, and reaffirms the contemporary intuition that cosmic evolution is one unified and interconnected process from "Big Bang to Global Civilization". For example, throughout big history the Physical Era was characterized by physicochemical evolution, the Biological Era was characterized by biochemical evolution, and the Cultural Era was characterized by biocultural evolution. However, there is no break or disconnection in this process, it is unified from the very start to the present. Humans divide Nature, but Nature is a whole. Atechnogenesis then suggests that this process will continue, and will move from biocultural evolution to technocultural evolution (Fig. 2.). This unified and interconnected process may be the product of deeper evolutionary laws, which currently remain elusive (see: Lineweaver et al. 2013b).

Figure 2.: Unified Cosmic Evolutionary Process



The process of evolution is far more inclusive and far-reaching than was originally thought (e.g., Darwin 1859). Cosmic evolution spans the whole of local universal history in one interconnected process whereby one form of change directly generates a new form of change. In this context the human species is a "bridge" between the biochemical and technocultural realms of complexity construction. We emerged with the generation of cultural symbol systems coding for new types of awareness, behaviour, and technology. We will then likely "transcend" this state and produce the next level of complexity construction, within which the technocultural pathway will gain its independence from biology: evolution fundamentally built on symbols, awareness, technology.

3.3. Big History in the (Real) Cultural Era

The big historian classifies humans as existing in the "Cultural Era". We live in an era where organisms organize chemical as well as symbolic information. But in the full context of big history, the Cultural Era is only a child, as it has yet to gain independence from its parent evolutionary pathway. Culture is still bound and limited, primitive and immature. We have not graduated from the chemical world to the symbolic world. The human species is still "waking up", "growing up", or "giving birth" depending on your preferred metaphor. "We are still unborn; we are still in a cave; Plato's cave." (Brown 1967, p. 37).

The future of culture, as well as language, technology, and mind, represent the largest sources of human ignorance, and therefore, should represent the frontiers of science and our inquiry of Nature. I suspect that any "end" to Nature will not be found in the physics of thermodynamics, but rather in the future of life and intelligence, and whatever life and intelligence produces. Essentially, if I am asked to bet whether inanimate or animate matter will "win", I will go with the animate variety. "It is impossible to calculate in detail the long-range future of the universe without including the effects of life and intelligence." (Dyson 1979, p. 447).

As discussed above, the trend towards greater disorder in the global universe has been overly emphasized in contrast to the opposing trend towards greater order in the local universe (Aunger 2007a; 2007b). And as of now, we have no real idea what culture, language, technology, and mind are doing and/or becoming. In short, we have only a scarce understanding of their cosmic nature (Dick 2009a). But any serious exploration of the future of culture, language, technology, and mind suggests that the human species is on the edge of producing phenomena that will change our understanding of literally every aspect of reality; consequently changing everything that even the most empirically well-grounded human worldviews currently take for granted. In other words: "Nobody knows jack shit about what is going on." (McKenna 1994a).

It is for this reason above any other, that we need a unification of the sciences and humanities. When these thought disciplines are merged, particularly related to questions on the human future, interesting thoughts and research directions emerge (see: Zimmerman 2008). Several branches and sub-disciplines of the humanities take culture seriously; take language seriously; take mind seriously. For the humanities culture, language, and mind are not an insignificant or irrelevant side product in an indifferent universe. Instead, culture, language, and mind are inner phenomena of equal (if not greater) importance to physics, chemistry, and biology. These phenomena create the realities and the universes, and they are as real as the outer objective material reality and universe. Therefore, when we talk about the next level of cosmic evolution we are talking about another level of thought and reality with higher experiential properties. And if our activities are about to produce a new and independent evolutionary process, then the birth and process of civilization development is an event on a comparable scale to the birth of the universe and the birth of life, as both the Big Bang and abiogenesis allowed for the emergence of independent evolutionary processes (see: Section 2.3.). The point here, fundamentally, is that awareness and phenomenological possibilities of our universe have been massively underestimated. The subjective has always been marginalized in the modern scientific worldview. But "Mental Things are alone Real." (Blake 1810 (1988), p. 565).

Scientists that speculate on the deep future focus their attention to the mechanisms that may enable higher intelligence or higher problem solving. But what we need is a deeper understanding of culture, language, mind, and how these phenomena will change the Nature of experience, all experience, and not just problem solving experiences. After all, if reality is experiential, there is a lot more to reality than problem solving. Indeed, if the last few decades of computer science have taught us anything, it is that problem solving is the most trivial of experiences. Replicating the inner exploration of opportunities for the pure sake of growth and enjoyment seems far more significant, perplexing, and mysterious. And biocultural humans innately and effortlessly engage in this form of replication. However, it is likely that technological life and mind will also develop these qualities, and so as we approach the real Cultural Era post-atechnogenesis, we approach new realities and universes, but they are not realities and universes of deep space, they are realities and universes of deep mind. "The only difference between computers and drugs is that one is too large to swallow; and our best people are working on that very problem." (McKenna 2001).

Radical theoretical exploration of the deeper waters of future culture, language, technology, and mind is still in its primitive infancy. Post-atechnogenesis, we enter the academic regions of the highest speculation. But here we put the concept atechnogenesis to its real practical test. The technological singularity concept forced us to imagine a black hole of experience, an event horizon beyond which we could know nothing about the deep future. In contrast, with the concept atechnogenesis we are confronted with a new evolutionary pathway, a pathway fundamentally:

1. Directed by aware minds
2. Built on symbolic/linguistic codes
3. Mediated by cultural idea/worldview sex

Therefore, the world of deep future speculation opens, and a vista of possibility is revealed; a possibility perhaps constrained only by imagination: "the end of our foundation" is "the effecting of all things possible" (Bacon 1626, p. 19). We can also use the theoretical grounds of cosmic evolution to make predictions. As we discussed, big history and cosmic evolution have been characterized by fundamental properties and trends related to both higher levels of information processing, energy control, overall complexity; and higher integration, variation, and compression. Our knowledge of the potential independence of the technocultural pathway, as well as our knowledge of the deep trends throughout big history and cosmic evolution, will guide us into the deeper future. "The books of an older period will not fit this." (Emerson 1837, p. 4).

Disclaimer: I make no comment on the nature of the transition (or the timing of the transition) from a world of biocultural beings to a world of technocultural beings (see: Section 3.1). I only make the assumption – grounded in big historical (see: Section 2.2) and cosmic evolutionary theory (see: Section 2.3) – positing that such a transition will occur (if we do not destroy the leading edge of complexity – ourselves – first) (see: Bostrom 2002).

The groundwork for what I call the "technocultural world" (as opposed to the biochemical or biocultural worlds) can be constructed using theory that we have already discussed at length. First, throughout cosmic evolution we have seen a steady rise in energy flows (Chaisson 2011a; 2011b), that have produced living system complexity further and further from thermodynamic equilibrium, and towards higher order (Aunger 2007a; Aunger 2007b). Also, throughout the history of living systems we have seen a steady rise in the ability to organize information with ever more complex biological or technological information processing systems (Corning 2002; Smart 2009). Therefore, the processes related to accumulated organization of structure via informational processes that has characterized biological and cultural evolution should be expected to continue into the technocultural world. The technocultural world would be a world with much higher information processing capability. The most likely mechanisms for higher information processing will emerge through advanced supercomputing (Blackford & Broderick 2014) and further integration and expansion of the Internet through the World-Wide Web (Heylighen 2014a). Likewise, the processes of energy control and allocation globally will also be much more efficient and abundant, likely leading to the elimination any material scarcity related to basic functioning for all beings. The most likely mechanisms for the realization of this energy future will emerge from either renewable energy (with solar shouldering a large percentage of energy production) (Bradford 2006), and/or nuclear fusion (For a complete analysis situated within an evolutionary framework, see: Niele 2005). Of course, this would all result in a technocultural world that is vastly more complex than the physiochemical, biochemical, or biocultural worlds: cosmic evolution on a whole new level. And so in the same way that the biocultural universe is more complex today than in its physicochemical and biochemical phases, the universe will become more complex in the technocultural phase.

From an evolutionary perspective we should expect the three main evolutionary trends to continue into the technocultural world. First, we should expect the level of integration to increase. Throughout human history we have seen the steady integration of smaller subsystems into larger wholes: from bands, tribes, kingdoms, nation-states, and now, larger international organizations (Stewart 2000). This trend should continue, and therefore the likely future human organization is as an integrated and highly cooperative global superorganism (Stewart 2014). However, the global superorganism should achieve this organization not through the further centralization of control systems, but rather, through a radical decentralization and distribution of control system organization that maximizes collective intelligence via the Internet (Heylighen et al. 2012). Thus, the future of human organization could progress via an odd combination of fragmentation of nation-state centralized control with integration of socioeconomic functioning from local-to-global (Corning 2005, p. 208). Such an entity would best be described as a “global village” within a “global brain” (Heylighen 2014a; Last 2014c). In this way, the integration of a complex global socioeconomic system will find stability through stigmergic processes (see: Heylighen 2015), the same processes utilized by biological superorganisms (see: Camazine et al. 2003).

Second, we should expect the level of variety to increase. Throughout human history increased variety has been produced through the specialization of cultural reproduction (i.e., increasing number of functional roles for the reproduction of ideas) (Wiener 1950; Kelly 2010). Due to the eventual complete democratization of information processing technologies and the elimination of material/energetic scarcity cultural reproduction should be completely controlled by the individual in the technocultural world. Individuals will no longer have to carefully coordinate cultural reproduction with the acquisition and stabilization of basic needs (i.e., food and shelter). This will lead to a dramatic increase in the variety of cultural activities and technological product (Heylighen 2007; 2008). Society will become a landscape of individually directed creation and experience, as opposed to a landscape of institution directed passivity and conformity. “Centralized”, “hierarchical”, or “top-down” institutions cannot hold the mind forever, thus they will all eventually become stigmergic (see: Heylighen 2015).

Finally, we should expect the continued trend towards space-time compression of complexity. Throughout human evolution this compression process can be conceptualized as part of a general trend that has been accelerating since the emergence of civilization, as biocultural humans (and our brains) have been concentrating in ever-more local (and dense) organizations. We have gone from foraging organizations, which shared the diffuse organization properties exhibited by other multi-cellular social foraging organisms, towards a species largely concentrated in mega-cities. These mega-cities are now becoming the localized hubs for the further compression of complexity in the form of advanced super-computation. Of course, this compression is also temporal, and consequently, the objective rate of change (or production of novelty) should also increase in the technocultural world. These rates of change or levels of novelty would likely be difficult for a biocultural human to comprehend. "[T]o self-aware postbiological systems, the dynamics of human thought and culture may be so slow and static that we will appear as immobilized in space and time as the plant world appears to the human psyche" (Smart 2009, p. 241).

So, in quick summary, within our big historical and cosmic evolutionary framework, we are likely to enter a technocultural world that has increased information processing, energy control, overall complexity, as well as increased levels of integration, variation, and space-time compression. This is the overarching predictive framework and vision that will allow us to now discuss the dynamics and experiential properties of the world technocultural beings could operate within.

First, we can say that the "being substrate" will be technological (Blackford & Broderick 2014). This opens up so many questions about the nature of being that one could lose their own mind in speculations; the mind becomes an infinite theoretical terrain. One of the most interesting and perplexing questions involves the nature of mind itself: will you be able to make copies? Backups? Will individual mind-copies be able to exist in parallel? (see: Sandberg & Bostrom 2008; Hanson 2014). Also, how will technological life reproduce if not via biological reproduction? The generation of mind children could take on a whole new meaning. Will physical space be completely ignored in favour of virtual space? If so, we are in the midst of a physical to virtual landscape transition, the likes of which have not been seen on Earth since the transition from water to land. These are all questions that may become central to philosophical inquiry in the 21st century.

Despite these mysteries, it is clear that there would be many advantages to "being" in the technocultural world, as opposed to "being" in a biochemical or biocultural world. The technological substrate would be far more malleable to conscious design, as opposed to the biological substrate, which is a fixed substrate of mind-less design. Technocultural beings will be able to interchange parts of their substrate, thus potentially making their substrate effortlessly self-transforming. In this sense, the body would become an art project for a technocultural being in the same way that clothing and various forms of cultural body decorations can become art projects for biocultural humans today. Perhaps the self-transforming body would be a form of a higher language, enabling technocultural beings to communicate the exact meaning of their thoughts and feelings to the external world.

Another important quality of the technological substrate is that it can be more easily controlled by mind. In a biological substrate, a biocultural being is subject to a certain tyranny in relation to sleep and food in particular. If your biological body is sleepy, well then it's time to sleep, or else it will be difficult to do anything else. If your biological body is hungry, well then it's time to eat, and so on. Although it is possible to develop a certain control over these processes – via the use of your mind – ultimately your biological substrate is something that must be "dealt with" if you want to continue existing and functioning. You must have a strategy for healthy biological maintenance (see: Heylighen 2014b). But in a technological substrate, the mind is likely to have far more control over the nature of conscious experience.

Of course, with mind fully in control of a self-transforming substrate, the very nature of the evolutionary process will be transformed in a technocultural world. Throughout the history of biochemical life, creation was a result of variation in biochemical reproduction. With the emergence of humans, creation became a biocultural activity, that is to say, a process of co-evolving variation in chemical and symbolic reproduction. In the 21st century symbolic cultural creation overwhelms the human experience. Our experience is filled with the emergence of novel behaviour, novel technological product, novel works of art and science. This all stems from the collision of new ideas and worldviews that can now interact with higher frequency and faithfulness in higher information mediums, most notably via the Internet.

In a technocultural world we should expect a planetary network of unprecedented cultural and technological creation. Qualitative modes of experiential expression we cannot currently fathom are likely to emerge and become commonplace. This can be seen as analogous to the way that symbolic art is commonplace for biocultural humans, yet completely absent in the biochemical world. Technocultural beings will be able to share extraordinary high levels of information at much faster speeds, and via much more reliable mechanisms. That is to say that the instant transmission of information files (i.e., books, movies, music, etc.) could be transferred between minds directly and understood near-instantaneously (i.e., "perfect memory"). All minds would have their own personal database and understanding of all knowledge. However, there would also be qualitatively different types of mind experience, as beings would be able to communicate vast reaches of the mind in a more intimate and interconnected fashion. Beings may be able to link minds and enjoy shared thought spaces and virtual recreations of any and all varieties. New forms of game, adventure, exploration, ecstasy, and mystery would present themselves to experiential realities, most likely in virtual space. There is no reason to suspect that the sharing of thought spaces would be limited in respect to temporal duration, or even to the number of aggregating minds.

In this world of cultural and technological creativity, the specific mechanism for the emergence of novelty would be the interaction and replication of ideas and worldviews (see: Veitas & Weinbaum 2014). We can find many parallels to this in the biocultural world, as the whole of human civilization is built on the sharing of ideas and worldviews. However, in a technocultural world the mechanisms for the replication of cultural symbol structures would likely occur in a more advanced form when compared to verbal language. In the biocultural world, the methods of replicating cultural symbol structures have always been outsourced to external mediums such as books, paintings, videos, and so on. We try to materialize our reproductive linguistic capabilities in order to more faithfully transmit meanings. We use higher replication of symbols to transport other minds to new conceptual universes. Technocultural life will likely be able to transmit meaning with experiential precision and literally transport other minds to new conceptual universes. In this sense technocultural beings would have a more intimate and complex method for translating the products of thought into the world of intersubjective communication. This would be likely to generate a high-level of symbiosis, peace, and harmony between worldviews. Much disagreement and conflict in the biocultural world is fundamentally caused from a failure to communicate inner meaning with the symbolic mechanism of verbal language.

New thought spaces could emerge from the generation of multiple mind mergers. There is no telling whether there would be a limit on the types of mind mergers that could occur. Cyberneticist Valentin Turchin thoughtfully contemplated the possibility of a deeply integrated human super-being under the apt sub-title "Questions, Questions" (Turchin 1977, p. 259):

"How far will integration of individuals go? There is no doubt that in the future (and perhaps not too far in the future) direct exchange of information among nervous systems of individual people (leading to their physical integration) will become possible."

Literary theorist Northrop Frye also approached this possibility from a different perspective (Frye 2004, p. 50):

"If the whole of mankind were once more integrated in a single spiritual body, the universe as we see it would burst."

But both thoughts attempt to convey a similar sense that the human species is still in a very primitive state compared the types of experience that could be produced via technological mediation. It will be interesting to see what happens if our mind leaves the cave. But of course, there is no telling what form such a being would take, what thoughts would emerge, what possibility would become commonplace. It would be like trying to compare the experiential landscapes of the first bacterial colonies of the Archaen Earth with the experiential landscapes of anthropocene New York City.

Technologically speaking the technocultural world could be composed of billions of "mindplex" like entities: "an intelligent system composed of collections of intelligent systems, each with its own theater of consciousness and autonomous control system, but which interact tightly, exchanging large quantities of information frequently" (Goertzel 2003, p. 2):

"[M]indplex is like a human society that has become so integrated and so cohesive that it displays the kind of consciousness and self-control that we normally associate with individuals."

Such entities would likely best be described as "super-beings", perhaps even capable of forming a "global being", or an interconnected "being-net" of "super-beings". From the perspective of biocultural experience, we may find our current phenomenological situation to be one spent in hyper-isolation.

The emergence of a global "super being" may seem overwhelming and difficult to comprehend, but as we have briefly discussed, the architecture for such integration is already being constructed (Heylighen 2007; 2008). The Internet specifically is the medium of interconnection, as it is behaving as a planetary neural network for the whole of humanity (Heylighen 2014a). Many researchers have speculated that humanity was in the process of forming a higher superorganism (see: Spencer 1896; Wells 1938; Teilhard de Chardin 1955; Turchin 1977; Rosnay 1979; Russel 1982), and many identified the Internet as an emergent brain-like superstructure (see: Stock 1993; Mayer-Kress & Barczys 1995; Rosnay 2000; Goertzel 2002). However, recent theoretical and mathematical models suggest that these thoughts could be more than just superorganism metaphors. The interaction patterns of humans via the Internet produce alluring similarities that may be analogous to the interaction of neurons in the brain (see: Heylighen 2012a; Heylighen et al. 2012). The emergence of a global brain combined with the development of supercomputing, artificial intelligence, and technologically modified biocultural humans, already gets us close to the edge of the technocultural world. The emergence of interconnected minds in some type of virtual space is likely not far beyond that landscape.

Therefore the deeper future of the Internet is key to the idea of hyper-integration of human minds. In a technocultural world, minds will be able to link up directly to a ubiquitous and truly global Internet; they will not need a computational mediator in the same way that biocultural humans currently do. This simply means that technocultural beings will be able to link to the Internet on command and as a part of their internal nature, they will not need an external computational medium like a laptop or a Smartphone. As a result, the technocultural being will spend much of its time in an Internet-based virtual space of a design that may be difficult for us to imagine. Indeed, if compression eliminates the constraints of both space and time the future Internet will become a planetary ocean for mind, the technological realization of “noosphere” (see: Teilhard de Chardin 1955). To view the modern biocultural world within this framework is to conceptualize our species as preparing the architecture for a departure into the unbounded imagination.

We must also confront perhaps the biggest of all the transitions between the biocultural and technocultural worlds. Throughout the entirety of life history, the game has been generation and death after generation and death. Beings pop into existence, struggle to make sense of existence, and then die. The human being merely added conceptual awareness to the struggle. But leaving the biocultural world may also mean leaving the game of generation and death. “The conclusion of the whole matter – Blake: ‘We are in a world of Generation and death, and this world we must cast off.’” (Brown 1967, p. 53). To think about the possibility of radical life extension is one thing (see: de Grey 2004), but imagining the world on the other side… is entirely different. “Effective human immortality will be achieved. And it’ll be the single largest discontinuity in human history. I wonder what’s on the other side though.” (Wolfram 2011). The only reference we have to imagine such a world comes from the Gods of our own cultural design. But what we can say is that the world of the technocultural being is on a whole different experiential level than that of the biocultural world. The biocultural human may not be able to handle effective immortality, but this will likely not be the case for the technocultural being. If technocultural beings possess some of the properties I have discussed above, they will be able to escape to new virtual worlds where the laws of physics are in their complete control. We will replace the laws of physics with the laws of the imagination. And therefore technocultural perception of both time and space may render all discussions of struggling with immortality obsolete.

However, when we think of the potential of the technocultural world in its totality, we start to reach a real breaking point in imagining a deeper future. What would such beings, or super-beings, be up to? What would be the nature of their goals, dreams, and visions? What would beings “beyond our cave” know about reality? How much of our understanding is shadow? How petty and primitive would historical biocultural humans appear? Surely we would look at least as primitive to them as the chimpanzees look to us. Or would we appear to be closer to the bacteria? To these questions, we may find ourselves with more questions than answers, although a few researchers have attempted to develop universal and quantifiable “sentient” or “consciousness” levels (see: Frietas 1975-79, 2008; Kaku 2014).

To really give these speculations on the *deeper* future some scientific ground to stand on, we must first entertain two scientific thought traditions about the human deep future. We will organize the first thought tradition under the banner “The Expansion Hypothesis” to describe theorists who posit the deep future of intelligence is destined to find itself among the stars and galaxies. We will organize the second thought tradition under the banner “The Transcension Hypothesis” to describe theorists who posit the deep future of intelligence is destined to leave this physical universe via “inner space-time”. Therefore, these two deep future thought traditions propose radically different deep futures, and both propose radically different potential natures to the intelligent universe beyond our local region. If we quickly consult dominant cultural representations of the deep future, it is easy to conclude that the "outer space" model of the deep future has been more influential. Although that is not to say that it is a more accurate representation of the nature of future intelligence.

4. Deep Future

Culture and technology are processes leading to infinity or Omega (see: Barrow 1998; Deutsch 2011). This may be something humanity has always intuitively sensed, as we have always imagined a higher future, whether from a religious, philosophical, or scientific perspective (Zimmerman 2008). And although it may have been easy to imagine physical human stasis before the Industrial Revolution, it now seems impossible to imagine our civilization as reaching some final equilibrium (Turchin 1977, p. 260):

"If we imagine that the human race will exist forever like a gigantic clock, unchanging and identical, with people (its machinery) being replaced as a result of natural processes of birth and death, we become nauseous; this seems equivalent to the immediate annihilation of the human race."

In this context: apocalypse and transcendence are our only deep future options.

Of course, human civilization is not without comparison. Entomologists have compared human civilization to insect superorganisms, and in many ways, this can produce interesting research related to organization, specialization, competition, cooperation, among other evolutionary phenomena. However, insect superorganisms have existed in more-or-less the same informational pattern for tens of millions of years (Hölldobler & Wilson 2008). Furthermore, it seems clear that they are stuck in this pattern; insect superorganisms can no longer increase their internal complexity (Morris 2013). In contrast, as Turchin recognized, it does not seem like humanity can be contained in the same way.

Vernor Vinge, the computer scientist and mathematician who originally coined the term "technological singularity" (see: Vinge 1993), played with the concept of endless human stasis (see: Vinge 2007b). In this paper Vinge essentially takes Turchin up on the challenge to imagine humanity as continuing for tens of thousands of years, or hundreds of thousands of years, without changing much at all. Vinge calls one of these future scenarios "The Age of Failed Dreams". During this Age we slowly realize that artificial general intelligence, deep space expansion, nuclear fusion, or any other fantastical future technological invention is beyond our abilities to produce. The human future then becomes a waiting game to see which physical phenomenon will knock us out first. Asteroid? Supervolcano? Our own star?

The point of the "Age of Failed Dreams" thought experiment is to emphasize that our species has yet to come to terms with the future of technological evolution. We are always in a process of becoming and changing; we are always seeking to learn something new or seeking to bring something new into existence that previously did not exist. We dream while awake, combining imagination with reason and evidence. Therefore, it is hard to imagine a human species lost and locked forever within an evolutionary labyrinth. We can always use our symbolic trails (i.e., history) to right our path towards a brighter future. So what is our final frontier? Will the universe exhaust us? (Apocalypse). Or will we exhaust the universe? (Transcendence).

4.1. The Final Frontier: Expansion Hypothesis

From the beginnings of the Scientific Revolution to the present day, humanity has imagined itself as becoming the future colonists of outer space (see: Kepler 1608; Voros 2014). Indeed, in some ways we can see a significant portion of frontier science production, as well as the creation of science fiction, as fundamentally dependent on the idea of human space expansion. In the modern world, the idea of humanity as becoming future space colonists exploded (see: Wells 1920; Tsiolkovsky 1929; Oberth 1957; Kardashev 1964; Dyson 1979; Asimov 1983; Tipler 1994; Sagan 1997; Landis 1998; Dick 2000; Hanson 2008; Stewart 2008; Bloom 2009). In this tradition of thought we can find the popular cultural representation of the Earth as our "cradle" (see: Tsiolkovsky 1911), and outer space our destiny (see: Clarke 1950). Today, many scientists view expansion as our only long-term hope: "We must continue to go into space for humanity. We won't survive another 1,000 years without escaping our fragile planet." (Hawking 2013).

In some sense, this can be seen as a logical evolutionary conclusion. After all, where else would we go after we have completely conquered (i.e., ephemeralized) STEM on planet Earth? There is an infinitely vast space-time continuum on the shores of Earth, populated with 100's of trillions of stars, and 100's of billions of galaxies. How many life forms exist in this infinite vastness? How many other life forms have developed culture and technology as well? Although speculative, our universe is so vast and structurally homogenous that it is far more probable that there are other forms of information processing being. Our existence could only be conceptualized as miraculous if we were truly alone among billions of galaxies. Therefore, the Expansion Hypothesis posits that the continuation of human history as a cosmic drama can surely be expected to outsource itself and play itself out in this cosmic arena, which, it can be safely assumed, will be populated by other beings (Dick 2000, p. 555):

> "Over the next 1000 years the domain of humanity will increasingly spread to the stars, a process that will alter our future in profound ways. At least three factors will drive this expansion: (1) increased understanding of cosmic evolution, changing our perception of ourselves and our place in the universe; (2) contact with extraterrestrial intelligence, bringing knowledge, wisdom, and problems of culture contact now unforeseen; and (3) interstellar travel, transporting humanity's emissaries to at least the nearest stars."

Material and colonial adventures abound in this deep future. Civilizations spanning multiple solar systems and multiple galaxies are still to be forged over deep time: cosmic organizational glory (see: Armstrong & Sandberg 2013). Maybe we will be able to see other galactic civilizations in the process of doing just this (see: Voros 2014). Interstellar and intergalactic communication mediums could be erected to facilitate the formation of these civilizations, and new forms of energy extracted from the hearts of stars and planets, could be commanded to power the existence of beings throughout the cosmos. We will climb the Kardashev energy scale (Kardashev 1964, 1997; Cirkovic 2004). The universe itself will finally "wake up", and eventually, mind will decide how it will end (Kurzweil 2005, p. 260):

> "Our civilization will then expand outward, turning all the dumb matter and energy we encounter into sublime intelligence – transcendent – matter and energy. So in a sense, we can say that the Singularity will ultimate infuse the universe with spirit[/consciousness]."

However, if we are going to entertain expansion scientifically we must situate our thinking within a cosmic evolutionary framework. Currently, the strongest evolutionary argument in favour of expansion comes from the work of theorists developing a progressively integrative model of living system complexity construction (see: Stewart 2000). In this model living systems are characterized by the evolution of ever-more integrated structures on ever-larger physical scales. From this line of thinking, it is progressive cooperation that will drive the cosmic process of expansion: proto-cells formed cooperatives to produce prokaryotes; prokaryotes formed cooperatives to form eukaryotes; eukaryotes have formed various cooperatives producing all multi-cellular fungi, plants, and animals (Corning 2005); and human beings are forming larger and larger cooperatives that should eventually reach a planetary scale (Heylighen 2007, 2008; Last 2014c; Stewart 2014).

From this we could extrapolate the process of higher and more integrated cooperatives on the scale of solar systems, multiple-solar systems, galaxies, and even galactic super-clusters (see: Armstrong & Sandberg 2013; Voros 2014). Such entities could be interconnected with some form of interstellar or intergalactic internet system, fuelled by the fusion of stars, and physically interconnected through some form of light speed (or faster-than-light speed) travel that is currently beyond our contemporary physics and engineering. Although current cosmological models of the universe suggest that colonizing the entire physical universe is impossible, or even nonsensical, we can still conceptualize a civilization that – through some technological wizardry of an unimaginable order – managed to completely reverse the entire process of cosmic expansion and control the whole of physical reality. We would call such an entity an “Omega Civilization”. Cosmologist John Barrow introduced the idea of “two forms” of Omega Civilization, with the aforementioned entity representing the expansionist variety (see: Barrow 1998). We will call this hypothetical Expansion Hypothesis variety: Omega Civilization-E: an entity that could “manipulate the entire Universe (or even other universes)” (Barrow 1998, p. 130).

Considering that the technocultural world is likely to be a realm of very high cooperation and integration perhaps this is the deep future for intelligence: the cosmic web as a playground for transcendent information processors. “Many centuries from now, will intelligent beings look back upon human history as an episode in the biography of cosmic *Geist*?” (Zimmerman 2008, p. 369).

This Expansion Hypothesis framework for thinking about the deep future can be made to fit nicely with our current cosmic evolutionary framework related to information, energy, complexity, as well as integration and variation. Each of these higher-level space cooperatives would need increased energy, information processing capabilities, and would therefore exhibit higher levels of complex organization. These entities would also produce far more variation, as likely manifest in forms of cultural expression and technological product that we cannot imagine. Of course, it is also possible in this scenario for variation to be produced through phenomena that currently do not exist. The only major trend throughout cosmic evolution that this framework ignores is the space-time compression phenomenon, which suggests that more complex order or organization emerges on more local scales of both space and time. However, we could explain this away with an interesting possibility: perhaps space-time compression *does* progress to a single dimensional point, before exploding throughout the physical universe producing a whole new cosmic Eon. STEM compression as a pathway leading to expansion.

However, this is not to say that the Expansion Hypothesis is without philosophical problems. Regardless of its popularity and intuitive appeal, we must remember that it is running on no empirical data: there is no evidence that intelligent life follows some developmentally constrained expansion to the cosmos; it is a logical conjecture, and nothing more. And yet the whole of the National Aeronautics and Space Administration (NASA), as well as the whole of the Search for Extraterrestrial Intelligence (SETI), have been influenced by its narrative construction. Because of this we rarely question the logic that both humanity and other intelligent beings, will go to the stars.

Let me be clear, stating that expansion is an assumption is not the same as stating that no expansion data will ever be found, or even that we should stop looking for expansion data. This is also not to say that we should stop attempting to explore our own solar system. I think NASA and SETI as organizations represent the very pinnacle of cosmic cultural thought as manifest in institutional structures, and deserve a much larger share of our attention and support. If SETI were to discover any intelligent civilization tomorrow, an understanding of its nature would likely completely revolutionize our understanding of the universe and Nature as a whole (For a fun SETI science fiction story on the discovery of "E.T." see: Shostak 1999). And if NASA developed some type of transportation device that allowed us to explore the Milky Way, then physical expansion would look like the obvious deep future for humanity. But as of now, the expansion of intelligence is still an assumption that we should consider, both seriously and skeptically.

Despite this, throughout most of science history, the Expansion Hypothesis has gone unchallenged. But there are now philosophical problems raising important questions about its probability. The most important philosophical challenge to the Expansion Hypothesis can be found in the realization that technological evolution on Earth is exponential. Essentially, this means that the biggest theoretical development forcing us to re-assess the assumption of expansion comes from the emergence and subsequent development of singularity theory (see: Section 3.1.). Singularity theory forces us to confront the fact that an intelligent civilization can evolve from a primitive technological civilization characterized by the telegraph and the horse-and-carriage, to an advanced technological civilization characterized by ubiquitous supercomputing and an interconnected global brain, within the cosmic "blink of an eye".

Immediately it is clear that there is something very strange about the nature of cosmic time vis-à-vis cultural time. On scales of cosmic time significant events and developmental processes occur on scales of millions and billions of years, if not even longer scales of time. In stark contrast, on scales of cultural and technological time, significant events and developmental processes occur on scales of decades and centuries. Increasingly, significant human events occur on scales of days, weeks, months, and years. Cosmic timescales and cultural timescales simply do not exist on the same temporal dimensional plane of existence. Cultural and technological processes are now stably harnessing the most intensive and dense flows of energy in the whole of the universe. These processes are continuing to intensify, generating stupendous levels of physical organization, of a variety and at a speed that is unparalleled when compared all phenomena in the known universe.

This is relevant to our discussion of the Expansion Hypothesis because of Fermi's Paradox (see: Davies 2010). Fermi's Paradox, simply stated, attempts to capture the bizarre fact that we have woken up in a vast and homogenous universe, which appears empty and silent. Yet here we are making all this noise. Thus, the paradox can best be conceptualized by physicist Enrico Fermi's immortal question:

"Where is everybody?"

No one has an answer for Fermi, and this is problematic for science and the scientific worldview (see: Bostrom 2008; Cirkovic 2009). Of course, the answer to why we detect no intelligence in the universe as a whole could be explained in many different ways. One of the most probable possibilities is that we simply do not have the requisite technology (or the necessary funding) to scan the entire universe in sufficient detail (as of 2014). As SETI astronomer Jill Tarter stated (2001, p. 511): "SETI results to date are negative, but in reality, not much searching has yet been done."

SETI's contemporary position is valid and I take it very seriously, but this does not help us evade the philosophical and theoretical challenge of technological singularity theory, and Moore's Law in particular. The simple fact is that all of the preconditions for advanced intelligent life have been present in our galaxy, as well as our Local Group of galaxies, for at least 4-5 billion years. That is to say that our galaxy has been a region of the universe theoretically conducive to the formation of life for as many as 10-11 billion years now (Rees 1997; Dick 2009c). Taking these data to their extreme, we find that advanced intelligent civilizations could be 7.5 billion years our senior (Vidal 2014a, p. 206). But we do not need that much time in order for Fermi's Paradox to become problematic in light of Moore's Law.

When Moore's Law is extrapolated to its logical conclusion, what we get is some pretty jaw dropping conclusions; even more jaw dropping then the near-term emergence of advanced technologically based superintelligence. The ultimate question with the nature of computation is: how fast can information be processed in our universe, given the known laws of physics? Then, based on the rate of Moore's Law, can we approximate when we will hit this information-processing limit? (see: Krauss & Starkman 2004). The current consensus suggests that the ultimate computer, or the ultimate "laptop", would be able to perform 10^{50} operations per second on -10^{31} bits (Lloyd 2000). Such a device would be in a highly ordered negentropic state, taking on the analogous dimensions of a space-time black hole (Lloyd 2000, 2006; Lloyd & Ng 2004). Based on Moore's law such an entity could conceivably be constructed by human civilization (or a post-atechnogenesis civilization) within 250-600 years (Krauss & Starkman 2004, p. 10):

> "Our estimate for the total information processing capability of any system in our Universe implies an ultimate limit on the processing capability of any system in the future, independent of its physical manifestation and implies that Moore's Law cannot continue unabated for more than 600 years for any technological civilization."

What this means for Fermi's Paradox should be clear: once an advanced civilization figures out the nature of computation, there is a possibility that it could develop into a black hole computing civilization. Such an entity would have compressed space-time to a dimensional point within a very short duration of time when compared to cosmic developments. Even if contemporary predictions made using Moore's Law are unreliable – as Seth Lloyd explicitly acknowledged (2000, p. 1053) – and it takes humanity an extra 1,000 or 5,000 or 50,000 years to develop the computational power of black hole computers, that would still be almost no time at all when compared to the scales of time that characterize solar system development or galaxy formation, and so on. Furthermore, even though Moore's Law is a property of human intelligence, not a property of physics, there is no reason to think that intelligence would somehow be prevented from ultimately reaching these computational capacities. From what we have observed in the 20th century, there will always be critics of the continued advance of computation. But Lloyd notes, every time we encounter some overwhelming obstacle: "clever engineers and scientists have found ways to cut the technical knot." (Lloyd 2006, p. 111). Therefore, if *any* civilization got their hands on this type of computation – *and* physical expansion is what advanced intelligence does – then the universe should show some clear and obvious signs of intelligent activity. "It takes but one match to start a fire; only one expansionist civilization to launch the colonization of the universe." (Bostrom 2010, p. 6).

Considered in this frame, we should *definitely* see the types of galactic macro-scale engineering hypothesized to exist by numerous theorists (e.g., Sagan 1973; Freitas 1975-79, 2008; Carrigan 2012; Learned 2012; Voros 2014). STEM compressed civilizations should be exploding in galaxies throughout the universe. This is a paradox worthy of the name. Although, given the nature and physical limits of computation, as well as the emerging data related to significant components of the Drake Equation (see: Impey 2007; Billings 2013), we may need to reformulate Fermi's question:

"No, *really*, where is everyone?"

The universe appears more than capable of advanced information processing (Barrow 1998; Wolfram 2002; Lloyd 2006, 2013), and our civilization gives the suggestion that advanced civilizations evolve culturally and technologically at a very fast pace when considered in a cosmic context (Sagan 1977; Turchin 1977; Kurzweil 2005; Smart 2009). Admittedly, many technological singularity theorists have realized this logical confrontation with Fermi's Paradox, and have essentially concluded: "We must be the first" (e.g., Kurzweil 2005; Bostrom 2010):

"[O]ur humble civilization with its pickup trucks, fast food, and persistent conflicts (and computation!) is in the lead in terms of the creation of complexity and order in the universe." (Kurzweil 2005, p. 239)

To support this view, the concept of a "Great Filter" has been deduced (e.g., Hanson 1998). The logic of the Great Filter is that our universe can generate hierarchical levels of complexity, but that it can only do so with 'great' developmental difficulty. The three main "threshold" hierarchical levels of complexity that have been targeted as potential Great Filters include the origin of life, the origin of multicellular eukaryotic life, and the origin of higher intelligence or technologically advanced beings (Hanson 1998; Bostrom 2010). This simply means that the universe may be poor at generating life itself, multicellular life, or high intelligence; or perhaps it is poor at generating all three. If this is the case, the Earth would represent a preciously unique example of a planet that "made it" through all three developmental Great Filters. Or alternatively, the Great Filter could be ahead of us, meaning that the universe can generate life, multicellular life, and high intelligence without difficulty, but then has difficulty generating an interstellar or intergalactic civilization (Bostrom 2010).

The Great Filter may be a useful concept, or it may be irrelevant (see: Aldous 2010), we simply do not have the data to say one way or another. However, by placing our own planet's history in a cosmic context, it seems like the Earth has had relatively little trouble generating any of the three "Great Filters". For example, life itself appeared on Earth's surface as soon as it was no longer a giant ball of magma (Bada & Lazcano 2009). Multicellular life evolved from unicellular life on 25 independent occasions (Grosberg & Strathmann 2007). And although only one species has developed evolving culture and technology (i.e., us), it is important to remember that large-brained organisms with primitive cultural behaviours and simple technologies have proven surprisingly abundant in the animal kingdom (Laland & Hoppit 2003). When you combine this fact with the consideration that all human biocultural evolution has covered a minuscule 2 million years of time (Last 2014a), and that the Earth has at least another 1 billion years remaining to support complex multicellular life (Franck et al. 2005), it stands to reason that if we had gone down a non-cultural evolutionary pathway, some other species would have, eventually. At the very least we can say that there are several candidate species that just need a little 2 million year ecological nudge towards higher neocortex functioning. However, we of course suffer in this analysis from the "observational selection effect" whereby any intelligent life that could conduct this analysis is by default existing on an unknown subset of habitable planets that did evolve and overcome these supposed "Great Filters". (Bostrom 2010).

In conclusion, contemporary science and philosophy stands at an odd place in relation to both Fermi's Paradox and the Expansion Hypothesis. The idea of expansion and contact with intelligence has fuelled some of the best science fiction, and it has also fuelled some of our most innovative science. But now there is an emerging spectrum of theorists who are exploring alternative possibilities. Therefore, it may be time to organize these alternative possibilities under the banner of the "Transcension Hypothesis".

4.2. The Final Frontier: Transcension Hypothesis

The Transcension Hypothesis does not have a deep and rich history, although from what I have managed to find, it does have a history (kind of). Systems theorist and futurist John Smart most thoroughly introduced the hypothesis recently, proposing that (Smart 2012, p. 55):

> "[A] universal process of evolutionary development guides all sufficiently advanced civilizations into what may be called "inner space," a computationally optimal domain of increasingly dense, productive, miniaturized, and efficient scales of space, time, energy, and matter, and eventually, to a black-hole-like destination."

Smart refers to this "black-hole-like" destination as a "developmental singularity" (see: Smart 2000; 2002; Smart 2009; 2012). Although, somewhat ironically, the term "technological singularity" would work as well, as the concept actually represents a space-time singularity generated by technology. In the 21st century, a number of theorists have essentially been attempting to reformulate our understanding of the deep future, as well as our understanding of the universe, within the framework of the Transcension Hypothesis. These attempts include theorists exploring multiple possibilities of the deep future (e.g., Farhi et al. 1990; Harrison 1995; Gardner 2005; Smart 2009; Martinez 2014; Vidal 2014a):

- Technological life "escapes" our physical universe through inner space
- Technological life "escapes" and acts as a mechanism for universe replication
- Technological life replicates universes and forms an integrated network with other intelligences

Thus, some variants of the Transcension Hypothesis overlap with the Expansion Hypothesis. However, modern Transcension Hypothesis speculations and predictions take a novel quality that is hard to compare to any scientific theory pre-late 20th century. One of the only clear exceptions to this can be found in the theories of paleontologist Pierre Teilhard de Chardin, as he predicted a very specific evolutionary deep future driven by increasing complexity and consciousness, and which ended here on Earth through the formation of a "noosphere" (read: sphere of human thought). Teilhard de

Chardin predicted that "noospheric effects" would generate "a whole layer of consciousness exerting simultaneous pressure upon the future" (Teilhard de Chardin 1955, p. 286). This idea may sound familiar to the idea of humanity eventually going through mind integration on a planetary scale. From these noospheric effects, Teilhard predicted that intelligence would compress towards "Point Omega" (or the "end of the world") where humanity would reach "maturation" and "escape" from the "material matrix" (Teilhard de Chardin 1955, p. 287-288). According to Teilhard, "Point Omega" would be a "single point" within which humanity "as a whole" will "reflect upon itself" (Teilhard de Chardin, p. 287): complete space-time compression leading to transcendence of mind.

The scientific community has largely ignored Teilhard de Chardin's predictions, mostly because of his teleological and religious evolutionary perspectives. However, we can say that his understanding of "noosphere" and "Point Omega" represent the first *clear* example of a Transcension Hypothesis-like prediction, at least to my knowledge. The criterion of evolution being developmentally constrained or attracted towards an "end point" is met, and the criterion of humanity as driving a process that will lead to us "leaving the physical universe" is met. Transcension; not expansion (Teilhard de Chardin 1955, p. 287):

> "I adopt the supposition that our noosphere is destined to close in upon itself in isolation, and that it is a psychical rather than a spatial direction that it will find an outlet, without the need to leave or overflow the earth."

This version of the deep future is far harder for the human mind to conceive, let alone understand. As stated above, the Expansion Hypothesis is in some sense helped in that it is intuitive. After all, human beings have already "expanded" to the Moon, and are making plans on expanding to Mars. We already have satellites dispersed throughout the solar system and even one satellite that has left the solar system (i.e., Voyager 1). We can also easily imagine interstellar space ships and the colonization of multiple planets. Obviously this is not only because there are countless science fiction books, comics, and movies specifically focused on this type of future, but also because we already live on a physical planet in a physical form. In contrast, we reach a very quick barrier to comprehension when we imagine a "hyper-local" future in "inner space" that potentially leads to an escape from the physical universe and/or replication of the physical universe.

However, in the late 20th century there were a number of theorists considering the possibility that intelligence, culture, and technology could either be mechanisms for the generation of new universes, or mechanisms that would allow us to eventually escape the gloomy picture painted by most cosmologists. Two major developments sparked flourishing of this theoretical direction: A) physicists theorized that intelligence could function to create baby universes (e.g., Linde 1988; Farhi et al. 1990; Harrison 1995; Got & Li 1998), and B) evolutionary biologists and systems theorists proposed that biological evolution was also a developmental phenomenon displaying remarkable degrees of general convergence (Kauffman 1995; Pennisi & Roush 1997; Morris 1998). Today many researchers are synthesizing these ideas with cosmic evolutionary theory to build a new framework for understanding the universe: Evo Devo Universe (EvoDevoUniverse.com). In the Evo Devo Universe framework the universe is understood as an interconnected cosmic developmental process resulting in the manifestation of global life history characteristics: birth, growth, replication, and senescence (Gardner 2000; Smart 2000, 2009). Of course, birth would be represented by the "Big Bang", growth could be represented by the local evolutionary process (see: Section 2.3.), and senescence could be represented by the "heat death" predicted by cosmologists (see: Section 2.4.). Therefore, culture and technology could represent the mechanisms for universe reproduction after the cosmic developmental growth process reached full maturation (Gardner 2000). Human intelligence, as manifest in our cultural evolutionary process, would seem to fulfill the necessary pre-requisites for replication: controller (mind) and duplicator device (technology) (Gardner 2005). And as stated above, this replication is predicted to occur within a developmental singularity created by technology (see: Smart 2000; 2012).

The Transcension Hypothesis, as formulated within the Evo Devo Universe framework, appears to be the strongest contender to the Expansion Hypothesis that has ever existed. And may also provide us with a new framework for thinking about astrobiology (see: Martinez 2014), including how we approach SETI in particular (see: Smart 2012). But how does this model work within our big historical and cosmic evolutionary framework? As we have covered, information processing, energy control, complexity, as well as integration, variation, and compression have characterized large-scale trends throughout the history of the universe. From this we can build the beginnings of a predictive model that will allow us to both A) chart these trends as our own evolutionary process accelerates, and B) predict what forms of living system organization we should expect to find in the cosmos.

The Transcension Hypothesis would suggest that human civilization is part of a general cosmic process constrained towards producing a developmental singularity (or maximum space-time compression). If this is actually a general process we should expect to reach the maximum information processing limits and the maximum energy control limits within our own local region of space-time. The manifestation of a living system organization that reaches the maximum limits of both information processing and energy control would represent an entity with both the highest complexity and the highest order in the known universe. In terms of information processing we have already discussed that physicists and computer scientists have speculated on mechanisms for the "creation of baby universes in a lab" (Farhi et al. 1990; Gott & Li 1998, p. 36), in the form of a black hole computer (see: Lloyd 2000, 2006; Lloyd & Ng 2004). Such a hypothetical structure could be programmed to "perform any desired computation" (Lloyd & Ng 2004, p. 56). And, as long as you do not hold the opinion that intelligence could never possibly build such a structure, due to some impossible technical hurdle, the real question becomes: what could possibly power such a device in a completely transformed technocultural world?

Of course, advanced nuclear fusion is one conceivable possibility. With the power to control "baby stars" one could conceivable power "baby black holes". However, an interesting possibility from an astrophysical perspective was proposed by philosopher Clément Vidal with the hypothetical concept of a "Starivore": a candidate energy structure to power a technocultural world with black hole computer(s) in the deeper future. In Vidal's own words (Vidal 2014a, p. 236):

> "[Starivore's] are slow non-conservative transient accreting binary, with the dense primary being either a planet, a white dwarf, a neutron star or a black hole."

The starivore concept falls within the Transcension Hypothesis speculations and proposes that intelligent civilizations eventually figure out how to compute at the fundamental levels of the physical universe, transforming their home planet (or "dense primary") into a hyper-dense computer device. The stabilization of this dense primary is achieved via the ability to control energy flow from their parent star, forming an organization similar to physical X-Ray Binary (XRB) systems (e.g., Eggleton 2006).

Starivore or no starivore, technocultural beings that manage to acquire maximum information processing would have driven all cosmic evolutionary processes – integration, variation, and compression – to their extreme. Therefore, in a Transcension Hypothesis future, the technocultural world we described (see: Section 3.3.) would appear to be very close to the end. This would mean that evolutionary space-time compression would bring us towards Point Omega. After the complete evolutionary conquest of dimensionality, we face a real black hole, a true technological singularity.

However, we should take a closer look at the phenomenon of space-time compression within the Evo Devo Universe framework. According to the Evo Devo Universe framework our universe as a whole is undergoing a process of Cosmic Convergent Evolution (CCE) (see: Martinez 2014). Therefore cosmic evolution itself will converge on similar structural solutions on its pathway towards the complete conquest of dimensionality. Throughout this developmental pathway evolution will gradually achieve higher complexity in more ordered structures that appear on ever-more local regions of both space and time (Fig. 1). Therefore, the compression of complexity may potentially be measured with the concept of STEM compression (Smart 2009). STEM compression suggests that as complexity increases local flows of matter-energy increase in density (Niele 2005; Chaisson 2011a; 2011b), while driving the localization of space and the acceleration of time. STEM compression and efficiency, if better understood, could then be used to make specific testable predictions about the future of cosmic evolution (i.e., the future of our own evolution), as well as make testable predictions within an astrobiological or astrotechnological framework (see: Vidal 2014a).

As of now, STEM compression and efficiency appears to be consistent with current long-term predictions for the future of computation and potentially the future of fusion energy. Advanced supercomputing will undoubtedly be a process that occurs from an understanding of computing on ever-smaller scales of the physical universe (Lloyd 2006). The whole evolution of computing technology involves the achievement of computing on ever-smaller scales of the physical universe. This phenomenon has been called the "Barrow Scale" to describe the hypothetical achievement of organizing matter at its smallest possible physical scales (Vidal 2014c):

Table 5: The Technological Barrow Scale

Nanotechnology	10^{-9}
Picotechnology	10^{-12}
Femtotechnology	10^{-15}
Attotechnology	10^{-18}
Zeptotechnology	10^{-21}
Yoctotechnology	10^{-24}
Plancktechnology	10^{-35}

The long-term future of human energy will also almost undoubtedly occur on more compressed scales of reality via the production of fusion energy, which is the ability to replicate the behaviour of atomic collisions, an inherently hyper-local phenomenon (Niele 2005). Considering that our universe appears "fine-tuned" for both advanced computation and controlled fusion, we may consider the possibility that we are currently on a developmentally constrained information-energy pathway leading towards universal limits of complexity. At the very least, these possibilities should command more of our attention.

We have already considered the remote possibility for an Omega Civilization-E (see: Section 4.1.). However, if we are on some type of constrained pathway towards increased compression, we may consider an alternative type of civilization: Omega Civilization-T (e.g.: Teilhard de Chardin 1955; Crane 1994; Barrow 1998; McKenna 1998a; Smart 2012; Vidal 2014a). Omega Civilization-T would represent the ultimate order and the highest complexity possible in the local universe. As a result of having achieved the highest information processing capabilities, it would be “capable of manipulating the basic structure of space-time” (Barrow 1998, p. 133). Presumably these technological abilities would either result in the generation of new universes or the complete transcension towards a different universe/reality/process (see: Smart 2009).

Of course, it is also possible that universe creation could also be coupled with some variant of the Expansion Hypothesis. Perhaps it is the case that Omega Civilizations-T are able to communicate throughout the cosmos via a type of physics beyond our current knowledge, consequently forming or merging into an intelligence web with other Omega Civilization-T entities. Perhaps the fusion of these entities (without the conquest of physical space) would eventually form an intelligence web throughout the cosmos, thus connecting the concepts of Omega Civilization-T with Omega Civilization-E. This suggestion is of the highest speculation, although it is certainly possible considering that we have no idea what most of the physical universe is actually composed of, and do not have a complete understanding of the laws of physics. The cosmic web could already be in the process of gaining intelligence. In fact, Pierre Teilhard de Chardin already considered a similar possibility (1955, p. 286):

> “Under the increasing tension of the mind on the surface of the globe, we may begin by asking seriously whether life will not perhaps one day succeed in ingeniously forcing the bars of its earthly prison, either by finding the means to invade other inhabited planets or by getting into psychical touch with other focal points of consciousness across the abysses of space. The meeting and mutual fecundation of two noospheres is a supposition which may seem at first sight crazy, but which after all is merely extending the psychical phenomena a scope no-one would think of denying to material phenomena. Consciousness would thus finally construct itself by a synthesis of planetary units.”

This gives us the vision of STEM compressed spheres of thought interconnecting throughout the galactic filaments of the universe. Admittedly, visions like these deep future Transcension scenarios stretch the imagination to the ultimate extremes. And yet, cosmologists have known for some time now that if one analyzes our local universe seriously within the context of the global universe, Transcension seems logical, even inevitable (Linde 1988, p. 29):

> “Investigation into the global structure of the inflationary universe suggests that the place where we live will probably evolve into an exponentially large black hole containing inflationary domains.”

There are many practical and theoretical implications if evolutionary compression is a local and/or general property of cosmic evolution in our universe leading towards Transcension, or some mixture of Transcension and Expansion. First, there is a type of revelatory quality to the knowledge that our civilization may be on a crash course with cosmic creation. Carl Sagan jokingly laughed off the possibility in *Pale Blue Dot* (1997, p. 186). However, a model that can adequately explain the emergence aware beings that mediate complexity construction with culture and technology should not be laughed off. If culture is a cosmic replication mechanism we must start a conversation about the potential theoretical implications for the relationship between religion and science as cultural worldview structures. In this model science and religion would appear to mirror one another as religion imagines properties of higher being (e.g., omniscience, omnipotence, omnipresence, etc.); whereas science attempts to physically realize (consciously or not) these properties of being.

In this context cosmic evolution as a whole we are confronted with the possibility that cosmic evolution is a developmental learning process, a type of cosmic ontogeny (Gardner 2005). Throughout the process of cosmic evolution the universe acquires more and more information about itself, and also develops the mechanisms to retain more and more of this acquired information. This results in deeper informational relations in the universe, which increases complexity, and may also enable the universe to become more aware or conscious of its own existence. We may view this basic observation as a reformulation of an idea formally proposed as the "Law of Complexity-Consciousness" (see: Teilhard de Chardin 1955). In this view, the cultural evolutionary process can be viewed as a part of a developmental process that is part of a larger cosmic ontogeny model: "Big Bang to Developmental Singularity" (Smart 2012). We capture the whole of Nature with our symbols and our technology, for the purpose of re-igniting the cosmic cycle. "The ultimate laptop looks like a small piece of the Big Bang" (Lloyd 2000, p. 1048).

The Big Bang to Developmental Singularity model is one in a series of models proposed by various scientists speculating about the potential evolutionary nature of the universe itself. The most well known cosmic evolutionary propositions were formulated within the concept of "Cosmic Natural Selection" (CNS). CNS models propose that non-intelligent black holes act as universe reproducers (see: Smith 1990, 2000; Smolin 1992, 1997, 2006). However, this conjecture suffers from the fact that the universe does not appear fine-tuned for black hole maximization, and also suffers in that non-intelligent black hole do not possess controller and duplicator functions necessary for replication (Gardner 2005). In contrast, the Big Bang to Developmental Singularity model falls within Cosmic Natural Selection with Intelligence (CNS-I) models (Smart 2009) (also referred to as Cosmic Intelligence Selection (CIS) and Cosmic Artificial Selection (CAS), see: Vidal 2014a). In CNS-I scenarios (see: Harrison 1995; Gardner 2000, 2003, 2005; Smart 2009, 2012; Vidal 2014a), intelligently designed black hole computers function as universe reproducers. Although speculative, both CNS and CNS-I would make sense with many theoretical physical models, which suggest that the fine-tuning problem requires the existence of multiple universes. That would add a whole new dimension to cosmic evolution.

Furthermore, the "Big Bang to Developmental Singularity" model reveals a type of "two-sided" universe related to order and organization. We may call the first side the "physical universe" which displays fundamental gravitational properties related to the accumulation of higher order. This simply means that higher energy densities and higher order accumulate in the physical universe via a type of gravitational attraction (Dyson 1971; Corning 2002). However, the second side is the "living universe" which displays fundamental informational properties related to the accumulation of higher organization (Corning 2002). In this sense, "control information" (see: Corning 2007) in living systems displays an analogous energy affect on complexity, when compared to the role of gravitationally mediated complexity construction in physical systems. Therefore, just as the physical universe can generate space-time singularities under certain gravitational pressure (i.e., black hole), the living universe may be able to generate space-time singularities under certain informational pressures (i.e., black hole computer). In our local region of the universe we may also think of these "two sides" as "two eons" (see: Aunger 2007b).

In regards to cosmic evolution, compression powerfully reinforces the notion that cosmic evolution is one interconnected and unified process with no separation from the "start" to the (potential) "finish" (see: Fig. 2.). Whereas the universe began with subatomic and atomic physical evolution, this process steadily accumulated ever-higher levels of complex organization via the associative nature of material structure. Eventually these evolutionary material associations may generate the highest complexity and the highest order possible in our physical universe. This associative nature – from atoms to molecules, from molecules to cells, from cells to multi-cells, from multi-cells to multi-individual societies, and so on – may need to be explained with some deeper law of evolutionary complexity. Complexity appears to be expressed in higher informational relations of increased variety, and in ever-deeper structure built from usefully preserved informational relations. This could mean that material cohesion is driven by attraction towards states of higher organization.

Also, compression suggests that we should make predictions based on an energy scale of ever more localized energy sources. Eventually we will be able to test between the two possibilities. Of course, considering that Expansion has influenced many of our theoretical approaches to both the "search" for extraterrestrial intelligence (SETI), and our attempt to "message" extraterrestrial intelligence (METI), we should at least consider the possible astrobiological implications of localized compression. This is for the simple reason that if we live in a universe where advanced intelligence hyper-localizes, we should not expect to find any macro-engineering projects of a galactic scale. Instead we should expect to find dense objects that stably control high-energy flows (see: Vidal 2014a). (For a more complete discussion on the implications for both SETI and METI see: Smart 2012).

Finally, and most controversially for many humans, is that we must confront the reality that mind is a real frontier, and potentially the final frontier. This is true regardless of whether Expansion or Transcension represent our deep future. This means that we will have to confront real change in our level of intelligence, perception, consciousness, awareness, and a number of other aspects of our fundamental phenomenological nature. Unfortunately, Western culture and Western science in particular have had tremendous difficulty understanding and confronting the reality of chemically induced changes to perception, consciousness, awareness, etc. (e.g., Huxley 1954; Leary 1965; McKenna 1993a, 1993b; Strassman 2001; Shanon 2003; Rodriguez 2007). Yet we are closer than ever to the reality of technologically induced changes to these phenomena. We have underestimated the implications of living in a universe where biocultural phenomenological experience could be dramatically superseded by technocultural phenomenological experiences. Mind may turn out to be an infinite terrain. Indeed, I think we can already say that it is close to an infinite terrain as can be imagined (e.g., Shanon 2003). But of course, this is not necessarily new information, but rather a plea to see existing information through a different paradigm. We have known for some time that the human mind is incredibly limited in terms of sensory perception, awareness, information processing speed, information sharing abilities, inter-connectivity, biological dependency, and so forth. All of these aspects of our mind's cognition are likely to be radically enhanced in the not-so-distant future (i.e., this century).

4. Big History: A Conclusion

Big history is a subject that offers academics the opportunity to study the whole of Nature, and not just some small subsection of its constituent parts. Consequently, this opportunity offers academics the chance to bridge all subjects and integrate human knowledge. Very interesting logical connections appear to emerge as a result of this integrative process. Therefore, big history may open a more diverse dialogue on a true theory of Nature that takes into consideration chemistry and biology, but also culture, technology, language, and mind. "All science has one aim, namely, to find a theory of nature." (Emerson 1836, p. 2). And no unified theory can emerge if we are only engaged in reductive science. The whole of Nature cannot be reduced to its constituent parts (Kauffman 1995, p. 2):

> "How do we use the information gleaned about the parts to build up a theory of the whole? The deep difficulty here lies in the fact that the complex whole may exhibit properties that are not readily explained by understanding the parts. The complex whole, in a completely non-mystical sense, can exhibit collective properties, "emergent" features that are lawful in their own right."

Investigations into the evolution of cosmic complexity – as studied within a multi-disciplinary big historical framework – offers us the chance to achieve what academics in disciplinary silos failed to achieve (Vidal 2014a, p. 16):

> "The sciences of evolution and complexity have the potential to bridge the gap between reductions to cosmology and particles physics. They are anti-reductionist by nature and seek to understand the emergence of new laws and of complexity transitions."

Modern evolutionary and complexity sciences also offer us the potential to make future predictions about ourselves in ways that may have appeared completely impossible just a few decades ago. For the first time since the discovery of thermodynamics and the exploration of the potential implications of entropy, scientists can now offer an alternative narrative of the deep future that does not inevitably end with mind giving way to heat death. The Physical and Biological Eras *may* end in thermodynamic equilibrium, but we should not underestimate the potential power of the Cultural Era. The Big Bang gave birth to physical evolution, abiogenesis gave birth to biological evolution, and human civilization appears to be giving birth to a completely new evolutionary process with properties that most academics have simply never seriously considered. The further development of artificial intelligence and advanced computing technologies this century will surely lead to a human civilization in 2100 that looks literally nothing like human civilization in the year 2000. "We won't experience 100 years of progress in the 21st century – it will be more like 20,000 years of progress (at today's rate)." (Kurzweil 2001). Our understanding of reality and nature is likely to be completely revolutionized in the process.

In my analysis, I have attempted to show that the study of the "deep future" can be explored within the subject of big history. Big history naturally lends itself to a structured analysis of potential deep human futures. This is because big history is identifying large-scale trends that can be correlated with increases in information, energy, and consequently, complexity. Of course, our ability to measure these phenomena is currently imperfect, and our knowledge and approach are certainly in their infancy. Both cosmic evolution and complexity science are subjects in their infancy. However, as complexity increases in our local region, we have the opportunity to test and make more refined predictions on the direction of our civilization. Of all phenomena in the cosmos, our own existence is what needs the most explaining.

Of course, all constructed deep future scenarios are untestable, and hence speculative. However, I believe that they are still worth our time and attention. After all, you cannot know where you are going, unless you know where you have been. Deep trends and processes have paved our way to the present; evolution is unlikely to stop now just because the subjects of the process have gained a conceptual awareness. Of course, existential risk is serious and could obviously alter the course of cultural and technological evolution. However, the fact that there are large-scale trends related to energy, information, and complexity, which manifest in an interconnected evolutionary process, should be enough to give us pause and consider deeply the implications of accelerating STEM processes. As our planet becomes transformed via the evolution of a deeper technologically mediated integration towards higher levels of complexity, we should at least have some reasoned perspective on where this integrative and complexifying process is likely to proceed.

All things considered it appears as though we should brace for an overwhelmingly novel 21^{st} century, characterized by historically unimaginable problems and opportunities. However, if we make good decisions, it is our privilege to guide humanity through a century of cosmic importance. “We are about to become unrecognizable to ourselves.” (McKenna 1998b).

Acknowledgements

I would like to thank John Smart, Clément Vidal, John Stewart, and Marios Kyriazis for their thoughtful and constructive feedback. I would like to thank the Global Brain Institute (GBI) and the Vrije Universiteit Brussels (VUB) for support and the opportunity to develop and share these ideas with the world, and in particular, to present these ideas at the International Big History Association (IBHA) 2014. Finally, I would also like to thank the authors I cited, who provided me with a wealth of data and playground of brilliant ideas, without which I would have never been able to produce this work.

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