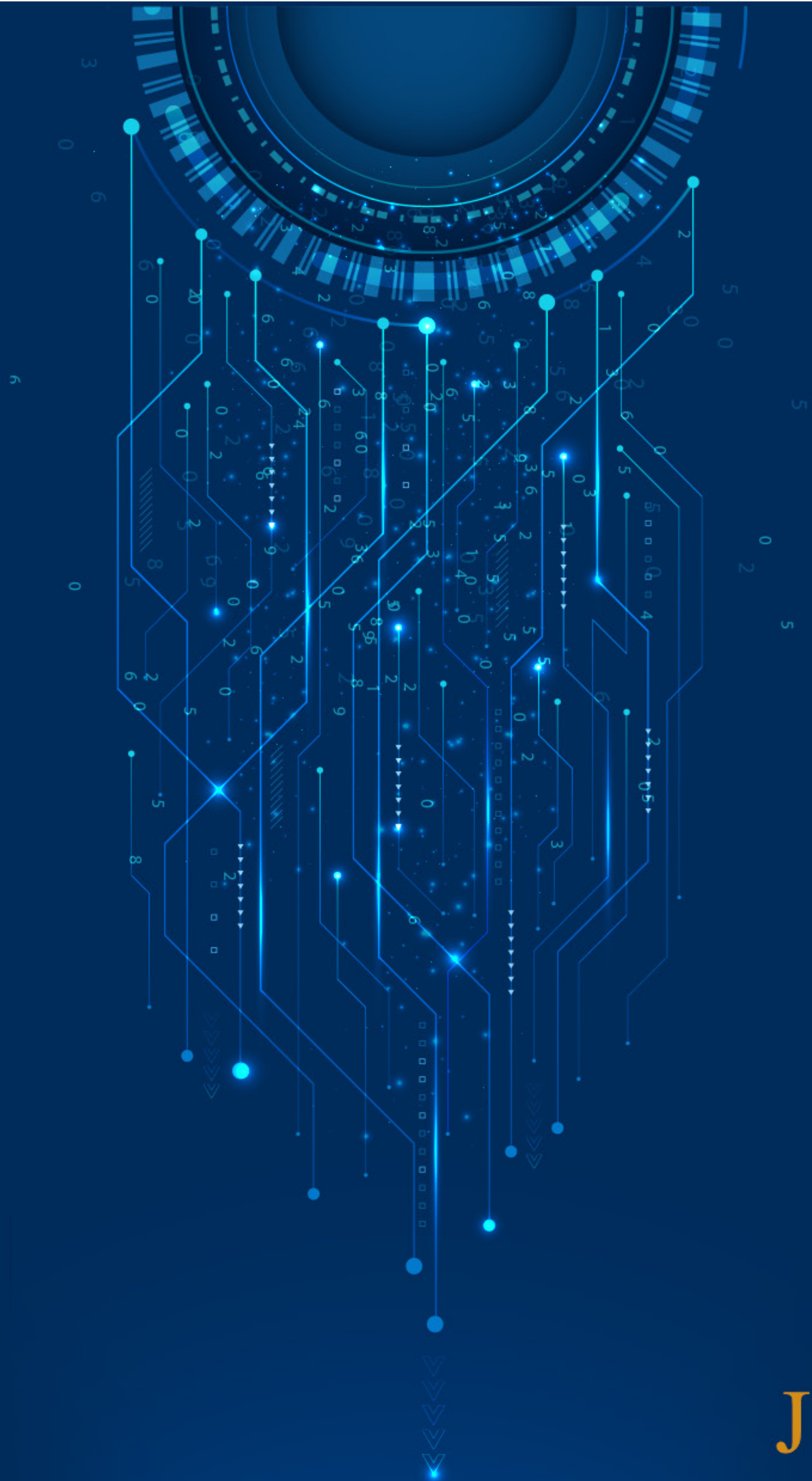

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A Big History of Land Clearance and Deforestation

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Abstract: The gathering and hunting humans who evolved from earlier manifestations of *Homo* changed the distribution of forests on the planet through their use of fire to direct biological productivity to their sustenance, and through their contribution to the elimination of much of the global terrestrial megafauna. Land clearance at any scale awaited the development of agriculture, the several independent origins of which may indicate that it is an emergent outcome from the combination of a social animal who can transmit knowledge through generations and who lives in environments that support high numbers of food plants. The transition from uncleared forest and treeless land to land cleared for agriculture was slow, often reversed, and limited by the necessity to produce more energy in food production than in the inputs that created comestibles. Increases in cleared land until the nineteenth century were largely a product of the displacement of gathering and hunting people by disease-ridden European agriculturalists and world trade imposed on non-Europeans by colonialists. The explosion in fossil fuel usage from the nineteenth century onwards enabled exponential growth in human populations and cleared land, with the consequence of a crash in forest cover. Ironically, attempts to mitigate global warming caused by increased fossil fuel use, deforestation and land clearance have resulted in more land clearance for biofuels. While settlements, roads, logging, plantation establishment and dam construction have all contributed to the decrease in the native terrestrial cover of the planet, their contribution has been minor compared to the massive impact of agricultural development.

1. Purpose and Definitions

During most of the long history of the physical and cultural evolution of the human animal, our interactions with the rest of nature were not without effect on the vegetation that directly or ultimately supports us, but the effect was probably no more than that of many other vertebrate species, such as penguins, or even invertebrates such as termites. Our development of fire technologies and commensal relationships with other mammal species resulted in vegetation changes over much of the planet but did not totally replace indigenous biotas. Our invention of agriculture marked a transition from modification to transmogrification. In the early 2020s, the transmogrification is extreme, with most of the terrestrial areas of the planet not having vegetation that resembles that of the early Holocene, only ten thousand years ago. The processes of clearance and deforestation are not slowing, despite their effects in exacerbating climate and biodiversity crises.

In this paper I address the history of land clearance and deforestation. I am concerned with both pattern and process: the spatiotemporal patterns of change; and the ecological and cultural drivers and accidents of change. I adopt an ecological perspective in placing human activity in the context of energy and material flows in ecosystems. My thesis is that clearance and deforestation are symptoms of the increasing capture of energy and material resources by one species, ourselves.

I define clearance as the replacement of native ecosystems with bare ground, artefacts or largely exotic ecosystems, where exotic refers to taxa that were not native to a locality before agricultural societies covered most of the world, and 'largely' refers to biomass, or the dry weight of the living things in the ecosystem, rather than the proportion of species, which is always biased towards native because of the profusion of fungi, microbes and other cryptic species found everywhere on the planet where conditions suit. In using accounts of land use change, such as that of Goldewijk et al. (2017) 'I do not count 'rangeland' as land clearance, because rangeland is typically largely composed of native species. Deforestation is defined as the elimination or reduction of trees to less than 10% projective foliage cover (Specht 1972). Trees are in turn defined for my purposes as woody plants more than 5 m tall, also following Specht (1972).

2. Our Precarious Planet

The limited set of conditions in which we know life occurs may be widespread in the universe. Alternatively, a series of random accidents, still ongoing, may have allowed life to develop on our planet in a nonentity solar system on the rim of a nonentity galaxy. Some of us appear to be desperate to find other life, elsewhere, to refute our suspicion of chaos and allay our fear of singularity. Yet, the history of life on planet Earth seems more consistent with the hypothesis of randomness, rather than inevitability. Our geological timescale is defined by extinctions caused by random meteorite strikes, random volcanic eruptions, random driftings and collidings of continents and the side effects of particular forms of life getting out of hand. Our planet, a non-renewable resource, wobbles around a sun that we believe is doomed to life-destroying bloating and eventual extinction.

During the last 2.8 million years, the planet transitioned from forest from the poles to the equator to a series of oscillations between icy extremes and slightly more balmy interludes, in which deserts were as characteristic of the terrestrial environment as forests. We are moderately confident that our species had nothing to do with this new state apart from labelling it as the Tertiary-Pleistocene transition, as we have no fossils closely resembling us from that long ago.

3. Life in Ecosystems

One way that our species thinks about the living components of the ecosystem in the 21st century is through the lens of Linnaean classification. The process of evolution can be gradual, as with the stooped ape to upright financial executive series we are so fond of depicting, or sudden, as with polyploidy, the doubling of chromosomes which prevents interbreeding. Both of these processes tend mostly to result in sets of populations of organisms that are relatively uniform genetically within and separated from other sets of organisms by genetically-based morphological or physiological discontinuities. Linnaeus labelled these plateaus in variation as species and formalised their nomenclature. Most were recognised in the vernacular before Linnaeus was born, First Nation taxonomies having been shown to closely resemble scientific taxonomies, with sometimes greater division of useful entities and lesser division of the superficially useless (Berlin 1992).

Species interact, most often in minor ways, but sometimes catastrophically. For example, the fox (*Vulpes vulpes*} is believed to be largely responsible for the extinction and endangerment of much of the marsupial fauna of Australia since its introduction in the 19th century (Woinarski et al. 2015). The principle of competitive exclusion states that no two species have the same position within the ecosystem, because if they did, one would competitively displace the other. So, the introduction of a new species will change ecosystem processes, as would the local extinction of a species, or even decreases or increases of populations of existing species.

A penguin trudges from the sea along a well trod path cut into the slope. An occasional predatory skua swoops. The path debouches into a wide bare space occupied by many other penguins, chicks at feet, an adult peck apart (Fig. 1). An occasional flurry marks a dive bombing from above. Subantarctic Macquarie Island saw no humans until the 19th century, land clearance being the province of penguins and

Fig. 1. A penguin breeding colony on Macquarie Island (Source: Collection of author). Note the complete vegetation cover in the absence of penguins and the pathway leading to the sea.

seals in their breeding colonies. Ecosystem interactions can result in the baring of ground of visible native vegetation we call land clearance or the mass death of trees that we call deforestation. Mammal and bird breeding colonies bare the ground, while outbreaks of herbivorous invertebrates can result in mass death of trees. These phenomena are likely to have occurred well before our ancestors ceased stooping.

More spectacular prehuman examples of land clearance and deforestation occurred through the agency of extreme climatic and geologic events. Volcanic eruptions, landslides, floods and fire are just a few examples of clearance and deforestation causal phenomena that are well documented in the geologic record.

Given that land clearance and deforestation are not just outcomes of the activities of the human animal, there is some interest in the degree to which we have been responsible, because responsibility implies a possibility of restitution.

4. Importance of Clearance and Deforestation

History cannot help but be written from perspectives that might have seemed bewildering to those who are its subjects. In 2022, the prospects for humans and other beings are clouded by linked crises: exponential climate change fuelled by human activities; accelerated extinctions of species; a high probability of conflict with nuclear weapons. In this context, it is not surprising that some of the themes that weave through the present paper are the energetics of agricultural systems, their effects on the rest of nature and the interaction of clearance and deforestation with conflict between human groups. Until fossil fuels dominated economies, the need to produce more energy than was spent producing food was so obvious that it did not need mention. Until the European conquest of most of the globe, it could be assumed that the elimination of species from a home region was unlikely to mean its total demise, in a context in which wild species and wilderness were seen as dangers to humanity, best eliminated, albeit with great difficulty. There would be no bewilderment in relation to warfare.

Land clearance and deforestation bear a large proportion of the responsibility for the steep part of the climate hockey stick, shown here for daily maximum temperatures in the city in which I live (Fig. 2). Food systems alone are estimated to account for one third of greenhouse gas inputs to the atmosphere (Crippa et al. 2021). Agricultural crops, sown pastures, deforested land under heath or grassland and even tree plantations hold and catch less carbon dioxide than the vegetation they replace. They have less biomass (weight of living things) than the original vegetation which in turn means that the carbon stored in the soil has a lower equilibrium level. These soil carbon stores can take centuries to reach equilibrium after a change in biomass, meaning that the great clearance and deforestation surge of the last few centuries still contributes new carbon to the atmosphere (Dean et al. 2017).

Given that clearance and deforestation are mechanisms to divert resources from other ends to human beings, other sentient and non-sentient beings suffer collateral damage. Not only are many individuals of species killed to protect crops and stock, the sustenance that innumerable species gained from the cleared and deforested areas is no longer available. The rarer of these species, and those concentrated in the habitats most valued by humans for clearing have been, and will be, pushed into extinction. That is an outcome that is generally seen as undesirable among contemporary humans, who have been known to reintroduce wolves to places in which they had been laboriously extirpated (Smith and Peterson 2021).

In the context of preventing extinction of other species, warfare can be a plus, if it devastates agricultural civilisations to the extent that their cleared land is reinvaded by native species, as was likely in the apparently symbolic salting of the fields of Carthage by the Romans when the whole population was enslaved and the city destroyed (Ridley

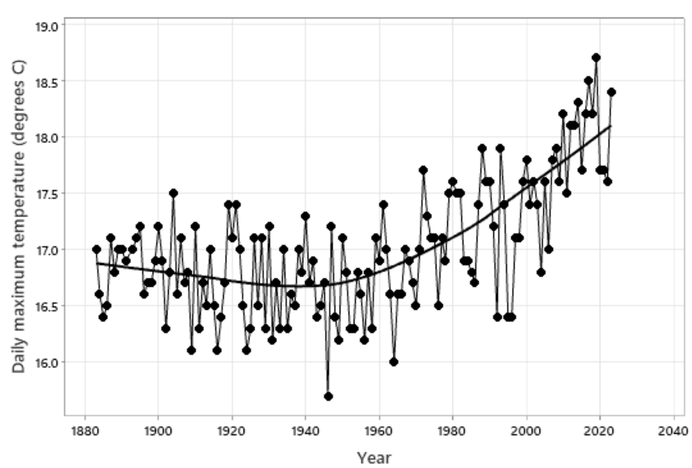

Fig. 2. Mean daily maximum temperatures by year for Hobart, Tasmania, Australia. Created by author from data from Bureau of Meteorology, Australia. Lowess line fitted.

1986). Nuclear warfare could not only cause global cooling, but also make much of the farmland humans currently occupy too dangerous to crop. The native plant and animal species have persisted after the Chernobyl power plant explosion (Deryabina et al. 2015), albeit not always in the peak of individual health (Mousseau 2021). The human population crash that would result from nuclear war may save a few other species. The abandonment of cleared land would result in a rapid uptake of carbon dioxide, mitigating or even reversing the hockey stick problem.

5. The Hair-Challenged Ape

There are probably no attributes of the morphology and behaviours of human beings in the species *Homo sapiens* that are totally peculiar to us. We have witnessed, or perhaps caused, the extinction of several other human species, some of whose genes survive within us. Excluding them from consideration, we can see non-human species, such as monkeys, using tools. Other species, such as whales, use language, predatory birds use fire, termites build complex cities, ants farm, bower birds create art, and wolves construct complex networks of social relationships. We have to be satisfied with degree, and emergent attributes from combinations of characters for our behavioural distinctiveness, rather than being distinct in kind. A lack of hirsuteness and the spectacularly large buttocks that keep us upright make us physically distinct from non-human mammals, but we are essentially the third chimpanzee of Diamond (1992), genetically almost identical to other mammals and not so genetically different from plants.

Our obvious animality would not have embarrassed our gathering and hunting ancestors but sits uncomfortably with the notion of human exceptionalism adopted by most of us today. If exceptionality exists, it is in the scale of our social relationships, and our ability to propagate and accept myths, ideologies and technologies among our global population as a whole (Harari 2011). As a small group social animal we have evolved to accept small group social and cultural understandings without critical thought, but also to use our verbal interactions with the rest of the social group to argue our path to better ways when they appear to be necessary. People have rejected old wisdom very rapidly once they subject it to discourse in changing objective circumstances. We have been a highly opportunistic species, capable of adapting to the ever-changing climates of the Pleistocene and Holocene by developing new technologies and fantasies.

6. Deforestation and Land Clearance by Gathering and Hunting Humans

The great attraction of prehistory to scholars is that the scant evidence can be incorporated into many different tales. Evidence is particularly sparse in relation to the time when humans evolved from their ancestral hominids. The multiregional origin hypothesis has been taken to suggest we began to evolve 1.8 million years ago, while, in an alternative more accepted hypothesis, our split from *Homo neanderthalensis* is suggested to have occurred between 550 and 765 thousand years ago (Stringer 2016; Galway-Witham and Stringer 2018).

The evolution from the predecessor taxon to *Homo sapiens* is likely to have been so gradual as to be imperceptible at the time, making the temporal boundary between the two taxa somewhat arbitrary. The sparse fossil evidence has been interpreted to mean that, for many millenia, we were one amongst several hominids. Breeding barriers between hominid species appear to have been weak, as were behavioural differences. For example, the people who left fossils since labelled as Neanderthal made tools and created artwork in caves. Their genes survive in the *Homo sapiens* genome. If one were a lumping taxonomist, there might be just one, not many, species of *Homo*.

Gatherering and hunting societies dominated the planet for most of human history and prehistory. Archaeological and anthropological observation have given us some insights to their functioning (Ingold et al. 2010, 2021; Sutton and Walshe 2021). Like chimpanzees, human beings formed social groups of about 20-30 animals who co-operated in gaining food, creating artefacts to collect the food and creating culture to stimulate their brains during the large amount of time not used for maintaining life. Based on observations of such societies by anthropologists, less than 15% of waking hours were devoted to activities that would be labelled as work in contemporary western societies. Human beings formed larger aggregations than the group which came together at places and times where and when food was profuse to talk, party and exchange genes. The groups that formed these predecessors of nations spoke the same languages, had the same customs and world views and sometimes fought with adjacent groups, although many were too peaceful for their own good when facing off expansionary agricultural or industrial people.

We know that gatherers and hunters who were observed by literate peoples were highly diverse in all aspects of life from who slept with whom to diet, which varied from almost entirely plant-based, as in some Californian peoples, to almost entirely animal-based, as in Inuit societies. Once established, they persisted indefinitely unless displaced by invaders, like the British in Australia, or environmental change, such as the sea level rise following the Last Glacial. Knowledge was effectively passed on through thousands of years through song, dance and story, as with the stories of the inundation of Port Philip Bay in Victoria, Australia 6500 years ago (Nunn and Reid 2016). Customs and culture appear to have reinforced the sustainability of resource use. People regarded themselves as part of the ecosystem, and often believed that their spiritual ceremonies, rather than their land use customs, bought food to their mouths (Sutton and Walshe 2021). People were a part of 'country'. That is not to say that gathering and hunting societies were totally static. There is evidence of rapid take up of new technologies. For example, dogs, *Canis familiaris*, were almost immediately adopted by the indigenous people when the British brought them to Tasmania (Boyce 2010). Archaeologists have documented many changes in technology, art and diet over many thousands of years, indicating our high adaptability to contingent circumstances.

Terrestrial megafauna are in short supply everywhere at present, but survived longest where human beings appear to have been the longest, in Africa. The suggestion that megafauna survived in Africa because they co-evolved with proto-humans and humans is attractive given the extinctions in large animal and bird species that followed soon after the human diaspora to places like the Americas, Australia, Malagasay and New Zealand (Burney and Flannery 2005). The hypothesis that invading humans hunted the young of big animals, thereby causing their extinction (Johnson 2006) does not imply that people wiped out species with intent, for the consequences of feasting on a young *Diprodonton* may not have been apparent until their parents died. However, if they knew, they may not have cared, many of the megafauna being notoriously bad neighbours. The species that became extinct after the first wave of humans tended to be those with a long period between birth and reproduction (Johnson 2006). Some scientists have questioned the responsibility of people for the extinctions of large animals in Australia and the Americas, preferring not to exclude climatic variation as a cause (e.g. Choquenot and Bowman 1998; Mann et al. 2019) in a context in which the climatic variation in some earlier glacial-interglacial cycles was much greater than in the last cycle when the large animals became extinct. The climate cannot reasonably be blamed for the extinction of Moas in New Zealand only a few hundred years ago.

As interesting are the debates about our degree of responsibility for the demise of big things, we are more concerned herein about the possible consequences of extinctions caused by humans on forest cover and bared ground. Mammoths may have enjoyed a decent wallow in mud, like elephants. Some of the extinct herbivorous species may have prevented trees from invading into grasslands or may have aided the spread of trees through endozoically dispersing and fertilising their disseminules, as is thought to be the case with *Macrozamia* in Australia (Burbidge and Whelan 1982; Hall and Walter 2013). These types of subtle consequences of likely human-caused extinction cannot be readily picked up in pollen, macrofossil, stratigraphic and archaeological records, mainly because the invading humans used the tool of fire to manage landscapes, a usage that almost certainly reduced forest cover and obscured more subtle impacts.

The amount of charcoal and the variety of pollen and macrofossils in sediments and organic deposits have allowed us to be confident that, in most parts of the world, the fire regimes that preceded humans were very different to those that followed our invasions into new lands, and that the change in fire regimes had a net effect of causing forest to retreat in favour of grassy ecosystems and treeless heath and scrub (e.g. Kershaw, Bretherton and van der Kaars 2007, Kershaw, McKenzie et al. 2007). This evidence is in the form of different vegetation and charcoal responses to glacial-interglacial climate change before and after humans invaded.

In Australia, the overwhelming of gatherers and hunters by agricultural people occurred only two centuries ago. The impact of gathering and hunting people on forests is much more easily deduced than elsewhere. There is no doubt that gathering and hunting people in Australia deliberately burned woody vegetation to produce herbaceous vegetation rich in food plants and game. Some of the strongest evidence is from the rapid reinvasion of trees after gathering and hunting societies were dispossessed (Fletcher et al. 2021) and from eyewitness accounts of burning by Indigenous people on the cusp of their dispossession (Gott 2005; Foreman 2020). These eyewitness accounts document the process of burning, down to the protective clothing worn by those engaged in ignition (Foreman 2020), as well as the process of protection of some vegetation from fire to provide shelter for hunted animals (Plomley 2008). Anthropogenic fires were usually small and patchy, burning to the footprints of each other, and only of sufficient intensity to set back invading shrubs and trees. Fire was also used in warfare between gatherers and hunters. Fires also occurred accidentally and from natural causes such as lightning and volcanic activity. In most places, fires resulting from natural ignition result in different vegetation structures to the fires resulting from ignitions by humans. For example, a five year interval between fires, adopted by gathering and hunting people in forests and woodlands in southeastern Australia (Gott 2005) maximises understorey grass cover (Kirkpatrick and Jenkinson 2022), whereas the more occasional large natural fires tend to result in dense woody understoreys.

Humans were not only grassland and savannah animals. Gatherers and hunters lived in and off forests in all parts of the world where forests could grow. Burning by humans did not prevent the reinvasion of forests into grasslands, tundra and treeless high country during the transition from the height of the Last Glacial to balmy and moist interglacial conditions of the Holocene. Burning by gatherers and hunters moved the forest boundary to a moister position than it would otherwise have been and tended to result in forest with open understories and fire-resistant trees, but the effects were marginal, rather than transformative, with climate change the main influence (Kershaw et al. 2002).

Behaviour with some of the characteristics of agriculture and animal husbandry has been well-documented for gathering and hunting people (Sutton and Walshe 2021), to the degree to which Pascoe (2014) argued that the gatherers and hunters of Australia were engaged in agriculture and aquaculture. Hynes and Chase (1982) coined the term domiculture to describe activities such as the replacement of myrniong (*Microseris lanceolata*) tops described by Gott (1982) and the placement of discarded parts of food plants on middens (Sutton and Walshe 2021). The distinction made between domiculture and agriculture is that the latter involves the intent to produce a new crop by planting seeds or tubers, whereas the former was simply food plants being reproduced by the discarding of their waste. Some of the examples given by Sutton and Walshe (2021) seem to involve intent, but certainly did not involve clearance or deforestation with the intent of producing food from agriculture.

Gathering of vegetable foodstuffs could be intensive enough to largely bare the land, as with the case of the myrniong. Gatherers and hunters also bared the land by building temporary or permanent villages and religious monuments, such as Gobekli Tepe in Turkey, where Harari (2011) suggests the urge to co-operate in constructing a religious monument could have motivated the domestication of wheat.

7. Commensalism Clears Forests

If one perceives that the whole landscape, living or dead, is sentient, as many gatherers and hunters appear to have done, even if in jest (Willerslev 2013), co-operation with other species might come easier than to a Cartesian dualist. If wild animals feel unthreatened they can be fed by hand and become attached to their feeder. If the feeding persists their young may be raised with the young of the other species, with the young most friendly to their providers being favoured in provision. Possibly in this manner, wolves evolved to become the dogs that love us, protect us and co-operate with us in hunting and herding our commensal grazing animals. The date for the domestication of the dog has steadily trailed backwards and will probably continue to do so. Mutation rates established through genomic analyses indicate a divergence of dogs from wolves 20,000 to 40,000 years ago. The oldest undisputed archaeological remains of dogs with humans is dated approximately 15,000 years ago (Irving-Pease et al. 2018).

The herders of Eurasia, Africa and the Americas replaced wild grazing animals with commensal grazing animals. Humans manage the landscape to maximise the flow of energy to our herds and thus us. We want savannahs and steppes, not dense, dank forests, so turned forest into lawn by burning and grazing. Sheep are particularly effective in suppressing woody regeneration after burning (e.g. Willems 1983). Goats preferentially consume woody vegetation with or without burning (e.g. Warren et al. 1984).

8. The Fall

The transition from gathering and hunting to agriculture and animal husbandry is likely to have been almost as gradual as the transition from proto-human to human. Agriculture may be an emergent outcome from the evolution of a social animal who can transmit knowledge through generations and environments that support high numbers of food plants, as it happened independently in several places. Gatherers and hunters controlled their populations in a variety of ways, ranging from extended breast-feeding to infanticide, all having the effect of living within the means provided by their territories. Why would they want to laboriously produce more food, when food was plentiful and took little and enjoyable time to obtain? The answer is usually 'by unfortunate accident'. This is the story of The Fall.

The story of The Fall involves the unconscious selection of food plants suited to fertile places disturbed by humans, the consequent establishment of permanent settlements, the growing of more food by breaking up the land and sowing seeds or burying vegetative material, and somewhere in this sequence, and most importantly, the easing or abandonment of social mechanisms for restricting population size.

Warfare was rife between many groups of gatherers and hunters, but not all, with deaths through violence judged from one set of skeletal remains in Sudan equalling 40% of all deaths, while other sets of remains elsewhere show next to no evidence of violence (Keeley 1996). Whether warlike or not, an agricultural band with a large population can easily displace gathering and hunting people from potentially cultivable areas, so agriculture and animal husbandry spread like a slow cancer from several independent nodes. The products of metastasis did not always persist, there being places where people abandoned agriculture to return to gathering and hunting, often because their agricultural activities were not sustainable (Diamond 2005).

Neolithic agriculturalists were the first of our species to clear extensive areas of land of native vascular plants. In the space created by clearance, they grew plants and animals that they domesticated into forms, physiologies and behaviours that suited their needs. As agriculturalist and pastoralists, we directed the energy of the sun and the nutrition of the soil to our own sustenance in places that formerly supported a rich variety and large biomass of non-commensal life.

Just because it is possible to grow crops does not mean that crops can be grown indefinitely. Early agriculturalists often cleared land then found it produced but one or two crops. Crops depleted nutrients, there was accelerated erosion and the loss of the cycling of nutrients between forest and soil prevented any replacement. The cleared land was thus rendered incapable of producing further crops in the short term.

The romantic wild heaths of western Europe are largely human-induced degradation states of forests that grew on low nutrient soils. Evidence of both cultivation and trees is found below the deep organic soils that now support a species-poor heathland (e.g. Prosch-Danieisen and Simonsen 2000). The removal of the trees by humans reduced evapotranspiration. Waterlogged soils and low nutrient levels slowed the breakdown of organic material, causing runaway paludification (the process of peat-forming). The peats drain more slowly than the sandy soils beneath, accelerating the process.

Agriculture on slopes often resulted in soils too shallow and rocky to cultivate as soil exposure results in accelerated erosion. The redistribution of sediment from slopes to valleys seldom improves the agricultural worth of either.

The deep red lateritic soils of the wet tropics (ferrosols) can become bricklike with the exposure to the elements that follows clearance. The nutrients in tropical forest systems circulate between ferrosol and forest in an almost closed loop, so the liberation of those in the trees by human burning is soon followed by a liberation to groundwater and out of the place. People eventually realised that if their agricultural occupation was brief, the forest would rapidly return, as would the fertility of the soil, fed by the cyclic salts in rainwater. People shifted their cultivation between years to preserve the positive balance between return in energy from crops and expenditure of energy in preparing and nurturing gardens (Rappaport 1971). Starvation was the reward for misjudgement of the time needed for resting beneath the regenerating forests, so shifting cultivation required ecological perception and cultural reinforcement of norms.

More fertile soils than ferrosols are found in the tropics, such as those that develop on basic volcanic deposits and alluvium derived from them in Indonesia and Niugini (New Guinea). Here the frequency of fallowing can be reduced, sometimes to zero. We are fortunate to have a record on film and in prose of the lives of a Neolithic (Stone Age) agricultural society in the highlands of Niugini (Gardner and Heider 1969). In the early 1960s, the Dugum Dani were untouched by the lives and customs of the post-Neolithic world. Warfare between adjacent groups was ritualised into a sacred part of the functioning of the society. The alluvial valley floor was decorated with a complex pattern of drainage channels and mounds on which a variety of tuberous plants were continuously grown. On the lower slopes of the high mountain valley shifting gardens were established by ringbarking large trees and grubbing out small ones, all with stone tools. The dried dead vegetation was then burned to fertilise the crops. The environment fixed the limit of human population, which was regulated into constancy by warfare and other less drastic cultural means (Gardner and Heider 1969). Like gatherers and hunters, Neolithic agriculturalists avoided the tragedy of starvation where possible by living within their environmental means, which the inhabitants of the nearby Baliem Valley did for 7,000 years (Haberle et al. 1991). Such avoidance was not always possible for those who lived on the flood plains of major rivers or close to active volcanoes.

Neolithic agricultural societies not only cleared vast areas of land by deforestation and/or drainage, as with the Dani, but also acted as geomorphological and edaphic agents. The construction of elaborate water distribution and diversion systems on flats and terraces on slopes was achieved with stone tools. Neolithic people also worked out how to turn poor soils, suited only for shifting cultivation, into soils suited to semi-permanent agriculture. The lazy beds of western Ireland mixed infertile peat with shells and marine algae (Bell 1984). The addition of charcoal to soils was worked out by many groups to help enable protracted cultivation. The legacy of this type of work is still seen in the terra preta soils of the Amazon Basin (Petersen et al. 2001). In the Niugini highlands, Neolithic agriculturalists of 1200 years ago worked out that a fallow cover of *Casuarina* trees would restore nitrogen to their soils (Diamond 2005). These discoveries enlarged the area potentially clearable and maintainable as cleared.

One major problem with agriculture is that it is easily disrupted by marauding pastoral hordes and other invaders; Assyrians descending on the fold. Once a crop cannot be sown or stock and stored food is destroyed or stolen, starvation awaits most of the victims, whereas in gathering and hunting societies their food persists until the invaders transform the landscape.

Agriculturalists who aggregate themselves can achieve population totals and densities well beyond the gathering and hunting band. They can afford the protection of armies. Such protection can be a twin-edged sword as the empires that develop are parasitic on agriculture, consuming its surplus. Those who rule and fool and kill in such empires are the last to starve if things go wrong, although emperors and kings had a high rate of violent demise even when things went more or less right (Saleh 2019). These empires may have enabled the expansion of clearing for agriculture to places previously recalcitrant, an expansion that was often associated with the development of the hydraulic civilisations of Geertz (1970). Hydraulic civilisations required an enormous degree of co-operation to maintain highly complex irrigation systems. This co-operation was helped by the development of religions that reinforced desirable complex social behaviours.

Hydraulic agriculture did not always result in a permanent transition from natural to cultural vegetation, witness the now largely infertile Fertile Crescent where agriculture may have first evolved. Hydraulic agriculture in arid and semi-arid regions outside perennial exotic rivers like the Nile is precarious, often being abandoned to desert more saline than when first cleared. Flooding by big rivers both replenishes fertility and flushes the soil of salt, enabling agriculture to continue indefinitely unless the sediments are trapped upstream by dams, as has happened in the twentieth century on both the Nile and the Yellow rivers.

Other major reversals of natural vegetation loss occurred in forested landscapes subject to cultivation but not irrigation. There are many examples, the most famous being the collapse of the Mayan and Angkor Wat civilisations, with other less well publicised examples in temperate North America and Zimbabwe (Diamond 2005). In all cases there is some evidence, often disputed (e.g. Pikirayi (2013) for Zimbabwe), that an incapacity to produce sufficient agricultural surpluses led to the demise of once-thriving nations, population crashes and a consequent reinvasion of forests. The agricultural systems were not sustainable at the level of intensity that became required to maintain empire. At some point the overworking or inappropriate working of the land caused negative feedback. Such collapses are argued by Diamond (2005) to be not inevitabilities in most cases, but rather failures of governance and the elite decision-makers, with agricultural systems in similar environments persisting at high levels of productivity.

In some cases, the collapse of agricultural and pastoral societies was a clear result of environmental changes that cannot be certainly attributed to human activity. Up to 5000 years ago, the present Sahara Desert was green, supporting many beneficiaries of the Neolithic Revolution. Changes in the global circulation system induced extreme aridity and the consequent retreat of most humans to oases and desert edges (Williams 2000, 2021). Similarly, the collapse of Norse communities in Greenland appears to have been at least partly associated with the climatic deterioration of the Little Ice Age (Diamond 2005).

The big success in hydraulic agricultural systems was wet paddy rice agriculture, the net effect of which was to conserve or improve the soil, the soil being kept in place on the terrace banks by human transport upslope and algae in the wet paddies producing vital nutrients. This form of agriculture has persisted on steep terraced slopes for thousands of years. The maintenance of dry land terraces, such as those widespread in the Mediterranean countries have also perpetuated land clearance on steep slopes.

Other big successes in persistence in dry land agriculture have been in places where it is almost impossible to destroy the soils, or where the soils are so deep that we have yet to run through them completely. Non-Mediterranean western Europe has deep soils that have been rejuvenated by the last episode of glaciation, when most of its area lay under a giant ice cap. During the few millenia in which agriculture has been present on the planet, the climate in this region has been mild and drizzly. Drizzle is far less likely to cause accelerated erosion of soils than more intense rain. The combination of rejuvenated soils and a gentle climate has allowed agriculture to persist for many thousands of years.

The transition from the Neolithic Age to the Iron Age in Eurasia and Africa was associated with the development of more efficient farming implements than were previously available, and much more effective tools to fell trees than were previously available. The invention of the wheel helped cement the empires by improving the transport of food and providing a new mobile means of warfare, the chariot. These technological developments seem likely to have caused increased clearing and deforestation, at least in the short term. However, in land clearance and deforestation, as in other areas of human endeavour, technological determinism does not stand up to close examination. Agriculture was developed independently in the Americas. So was metallurgy and the wheel. Yet, metals were used only for ornament and the wheel for toys (Mann 2011). Empires and irrigation nevertheless abounded (Mann 2011).

9. The European Hegemony

The explosion of Europeans over the surface of the earth in the sixteenth, seventeenth and eighteenth centuries was powered by the renewable energy of wind for transport and the renewable energies of wind and water for industry. It was facilitated by the susceptibility of populations in many other places to the cornucopia of diseases that infected the Spanish, Portuguese, French, British and Dutch, but were novel and often lethal in differently diseased populations (Diamond 1997). Steel weapons may have helped a little (Diamond 1997).

The Americas were depopulated by diseases introduced by Europeans. There is debate on the estimate of 95% of a population of 90-112 million people killed by introduced diseases (Dobyns 1966), but there is no doubt that there was mortality massive enough to facilitate the Iberian, French and British conquests of the Americas. The natural revegetation of previously cultivated areas in the Americas in response to this human population crash has been suggested to be a possible cause of the Little Ice Age. (Lewis and Maslin 2015). The expansion westwards of the 'frontier' in the United States felled forests that had invaded previously cultivated land and occupied prairies created by extinct civilisations. There seems little doubt that much of the Amazon Basin was cultivated, including large areas of food forest along the river itself (Mann 2011).

The British invasion of Australia in 1789 introduced land clearance and logging to the continent (Kirkpatrick 1999). It also introduced stock, some of which were grazed with such intensity in native vegetation that they prevented tree regeneration, compacted soil, promoted shrub invasion and converted streams that meandered moistly through flats to flash-flooding incised gullies. The native eucalypts are difficult to clear, resprouting readily from underground organs called lignotubers after fire or felling (Kirkpatrick 1999). In more temperate parts of the continent, persistence was widely rewarded with cropland and sown pastures reminiscent of East Anglia or the Cotswolds down to the hawthorn (*Crataegus monogyna*) hedges.

Sailing ship technology enabled the transport of the produce of far distant colonies to Europe, which fueled its population growth by clearing far flung lands, the native inhabitants of which either would not have cleared, as in the case of Australia, or had no reason to produce more than they consumed. Taxes in a money economy fueled by debt and enforced by armed men provided motivation either for the native people that survived the shock of colonisation or the colonisers with their African slaves. The Little Ice Age gave way to the handle of the hockey stick.

10. The Great Release

The frontier mentality and the capitalist mindset had taken hold of many populations by the early nineteenth century, but most frontiers had met sea or inland desert and capitalist economies constantly required new resources to avoid crashing. The world without fossil fuels was limited in its scope for expansion of populations and wealth. It was caught in the Malthusian trap – population cannot grow beyond the capacity to feed it, while tending to grow to this limit. Our species temporarily broke out of this trap by using the energy trapped in organic detritus in dinosaur-ridden Jurassic swamps. Coal, then oil and gas, freed agriculturalists and other food producers from the age old necessity of producing more energy than they put in, until, in the early 2020s there is hardly a food product on the market that provides more energy than it costs to produce (Carlsson-Kanyama et al. 2003).

Fossil-fueled industrial agriculture has resulted in a massive increase in the area of cleared land on Earth (Goldewijk et al. 2017, Fig. 3). Although estimates of increases in cleared land vary, there is no doubt that there was an order of magnitude increase from less than 10 million hectares in 5000 BC to over 2000 million hectares in the second decade of the twenty-first century and that most of the increase took place after 1850 CE (Fig. 3). In 1850, each person was supported on average by 0.65 ha of cleared land, while in 2015 there were 0.29 ha per person (calculated from data in Table 6 in Goldewijk et al. 2017). The population growth from 1271 million to 7301 million between 1850 and 2015 (Fig. 4) was reflected in a damped way in massive increases in the area of cleared land, from 831 million hectares to 2103 million ha (Fig. 5). Even in Great Britain, where there was no primaeval forest left in the early nineteenth century, native vegetation has suffered a precipitous decline. For example, hedgerows have been dramatically depleted to facilitate the cultivation of machine-managed crops (McCollin 2000).

The economic cost of converting natural vegetation to agricultural or pastoral land has declined dramatically as energy has become cheaper and machinery more effective. It was a life work for a family to clear a farm in the nineteenth century, but it is now a matter of mere days for an operator of a massive yellow machine.

The history of land clearance since the early nineteenth century consists of a series of rapid expansions enabled by technological advances, less than balanced by an occasional retreat. Australia is an exemplar of this process (Kirkpatrick 1999). In 19th century Australia, ringbarking, felling with

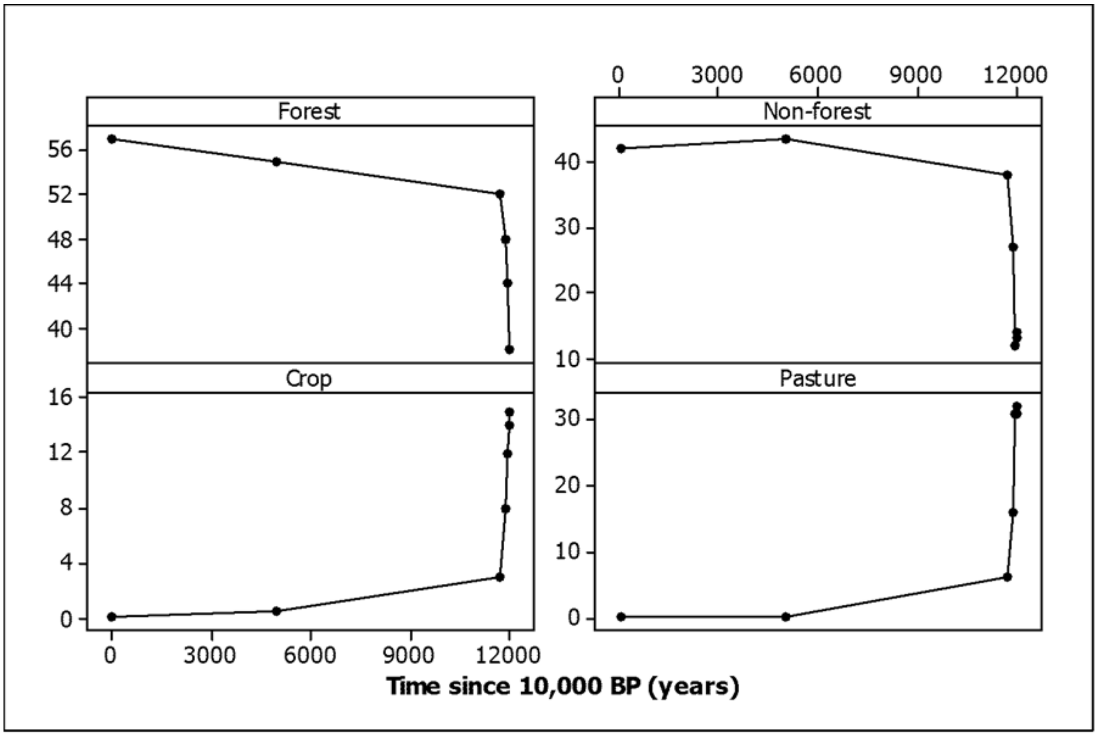

Fig. 3. Temporal change in forest vegetation, non-forest vegetation, crops and pasture as percentages of total planetary land area (https://ourworldindata.org)

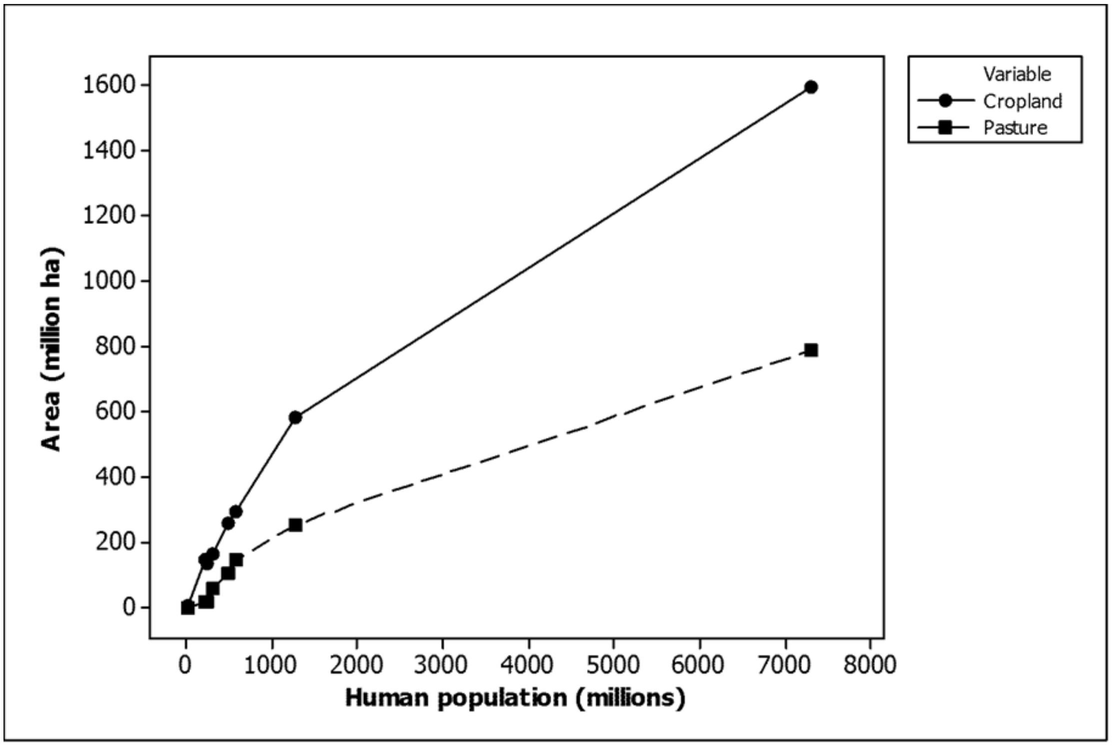

Fig. 5. Area under crops and pasture related to human population (data from Goldewijk et al. (2017))

axes and burning was used to clear forests on fertile, well-watered land, while woodlands and grasslands on fertile land were ploughed and enclosed or just grazed. Much of the cleared hill country was too steep and broken for later agricultural systems, so was allowed to return to forests that largely consisted of native species but were distinct in their composition from the original old growth. A massive expansion of cleared land took place in Australia in the mid twentieth century after the discovery that the addition of phosphorus, nitrogen, potassium and trace elements could make the soils under native heathy ecosystems productive for crops and introduced pasture. The development of cheap industrial fertilizers also resulted in native pastures being converted into exotic pastures. The latter were more productive in wet years, although poorer than the native pastures in dry years. Field agriculture had almost become hydroponic. The effective limits to clearing were imposed by topography, the availability of water and protected areas.

Some of the massive areas cleared in the wheat-sheep belt of Australia were lost to salinisation, but most continue to be cropped by virtue of the nitrogen drawn from the air using fossil fuels and the mining of phosphate and trace elements such as copper. Clearance and fertilisation technologies almost completely took out one ecosystem after another. The brigalow (*Acacia harpophylla*) forests that covered much of northern New South Wales and southern Queensland almost disappeared in a couple of postwar decades. A similar fate has befallen the Brazilian cerrado and, much earlier, the prairie grasslands of North America.

11. Logging and Deforestation

While most of the dramatic loss of forest (Fig. 3) has resulted from clearance for crops and pasture (Hughes and Thirgood 1982; Deacon 1999; Kaplan et al. 2009), other uses have had both direct and indirect effects.

Wood from trees has been used for heating and cooking since humans and their predecessors used fire as an everyday tool, many hundreds of thousands of years ago. The bark, small branches and fallen branches of trees were used by gatherers and hunters to make shelters. Bark was also used to make canoes and fish traps. Trees may have been killed by land management fires, but few were felled for their timber. The Neolithic revolution involved the construction of permanent dwellings and communal buildings, activities that often required the felling of trees for structural timber. Since the Stone Age the logging of forests has been a major human activity, the felled trees being used to produce commodities as different as paper and wooden warships.

Logging does not necessarily result in deforestation. Trees are tenacious in their grip on previously possessed land. The regenerating forest might have a different structure and even a slightly different species composition than the primaeval forest but is still forest. However, logging often requires access to previously remote areas. Access can facilitate clearing for agricultural development, as in Niugini and Brazil in the late twentieth and early twenty-first centuries. Roads, subsidised by the lucrative free good of logs from natural forests, enable access for the clearers and a way to get their produce to market. Roads are also associated with human-ignited fires, which can penetrate the logged forest at times when burning unlogged forest is not possible. These fires can eliminate the forest if repeated. Repeats are almost guaranteed, as each fire makes the former forest site more flammable. The removal of vegetation by repeated flames facilitates the clearance process.

Forests can be felled for plantation silviculture as well as agriculture (Barua et al. 2014). The growth of forest plantations globally has been rapid over the last two centuries, conforming to the hockey stick meme.

A contorted small rare coastal tree from California, Monterey pine (*Pinus radiata*) has been turned by selection into a rapid growing erect, self-pruning tree that was grown in large plantations in the southern hemisphere in the twentieth century. In New Zealand, the extensive plantations of Monterey pine were so much more productive in wood than the native forests that the remaining native forests on public land were devoted to conservation. In Australia, logging of the native forests continued as more plantations were established. The native Australian timber trees, mainly eucalypts, grow as rapidly as radiata pine. One of these eucalypts, the Tasmanian blue gum (*Eucalyptus globulus* ssp. *globulus*), is widely grown in plantations in places as diverse as Western Australia, Ethiopia, Chile and California. However, in the natural range of Tasmanian blue gum, southeastern Australia, a related species from Victoria, shining gum (*Eucalyptus nitens*), has been grown in extensive plantations since the 1970s. A high proportion of these plantations were established by clearing native forest.

As with agricultural crops, when a new profitable timber tree is developed there is an explosion of planting, often on sites that ultimately prove unsuitable for its growth. Plantings of shining gum displaced native forest and grasslands on basalt at Surrey Hills in the montane zone of Tasmania only to fail or grow extremely slowly. Plantations of eucalypts in California persist in the landscape but proved of little use for their intended purposes (Kirkpatrick 1977).

12. Mining and Land Clearance

From the ochre pits of gathering and hunting people to the massive open cuts of today, mining involves baring land to extract minerals from the surface of the earth. Mining activity is usually brief, soon abandoned because of economic exhaustion. Revegetation is usually rapid, except if the surface is poisoned by heavy metals, in which case revegetation may take many decades (Fig. 6).

13. Urbanisation, Transport and Land clearance

Human settlements and terrestrial transport routes have occupied an exponentially increasing proportion of the planet to the point at which approximately 1 in 100 hectares of land lie under tarmac and towns (Liu et al. 2020). A few native trees may survive the transition from native vegetation to settlement only to become too large or dangerous to keep among our houses, factories and shops. Some of the clearance for urban areas is for constructed parkland in which our species can hit or chase balls, run around in circles or ellipses or eat and sleep outdoors. However, some substantial tracts of uncleared vegetation are characteristic of cities in the more wealthy parts of the world. For example, London has fourteen percent of its area under tree cover, a large part in extensive parks like Hampstead Heath. Many of the larger tracts of native vegetation in European cities survived because they were pleasure parks for the ruling class. They were later to become democratised. In the nineteenth and twentieth centuries, planned cities were often provided with extensive natural parklands, such as those that surround the central business district of Adelaide, South Australia, and Kings Park in Perth, Western Australia.

Like agricultural land and mines, settlements and roads rapidly naturally revegetate once abandoned. The vegetation usually does not closely resemble that cleared for the roads

Fig. 6. Revegetation of the copper refinery induced Queenstown Desert between 1972 (top) and 2020 (below) (Collection of author). Zinc and copper deposition were responsible for total vegetation loss. Smelting of the ore ceased in 1922.

and settlements, as it occupies land that has very different environmental characteristics to the preclearing ecosystem.

14. Nature Conservation and Land Clearance

While living off the surplus of those no more able to gather and hunt, the rulers of complex agricultural societies spent much of their time in the atavistic behaviour of hunting. Gathering was not one of their major activities, reflecting the sexist nature of these societies. Good hunting requires good land, so lords, kings and emperors conserved nature on lands that would otherwise have supported more peasants. The fantasies that enabled kingdoms and empires were occasionally the only protection against extinction.

'The many species in the later hunting grounds of the rich benefited from a particularly pernicious political fantasy of god-given social stratification. In the nineteenth century a national park movement arose in the United States of America, to prevent the destruction by agriculture and logging of outstanding natural landscapes; to enable them to persist for the benefit of all people. The designation of these wild areas as 'natural' ignored the fact that they had been co-created by First Nations and were still adjusting to their absence. These wild areas were, in fact, original human habitat without the original humans, who had been killed and displaced by the ancestors of those promoting the parks.

National parks and other areas devoted to nature conservation provided some limits to land clearance and deforestation. These limits did not restrict clearance and deforestation to any great degree, because the type of land placed in the early national parks was highly romantic, with much craggy relief garnished with water or ice features. If national parks became desirable for the construction of dams, or proved to have some loggable forest, their revocation or submergence was not a great political problem up until the 1970s, when resistance to the loss of parks to development became strong in some 'New World' countries, such as Australia.

Attempts to protect viable areas of ecosystems that are approaching extirpation from land clearance began to have some effect in the late twentieth century, with the expansion of both public and private protected areas focused on poorly-conserved elements of biodiversity. These protected areas have proven partially effective in rich countries, but nominal in most poor countries, unless there is strong cross-subsidisation from the rich. It has not been possible

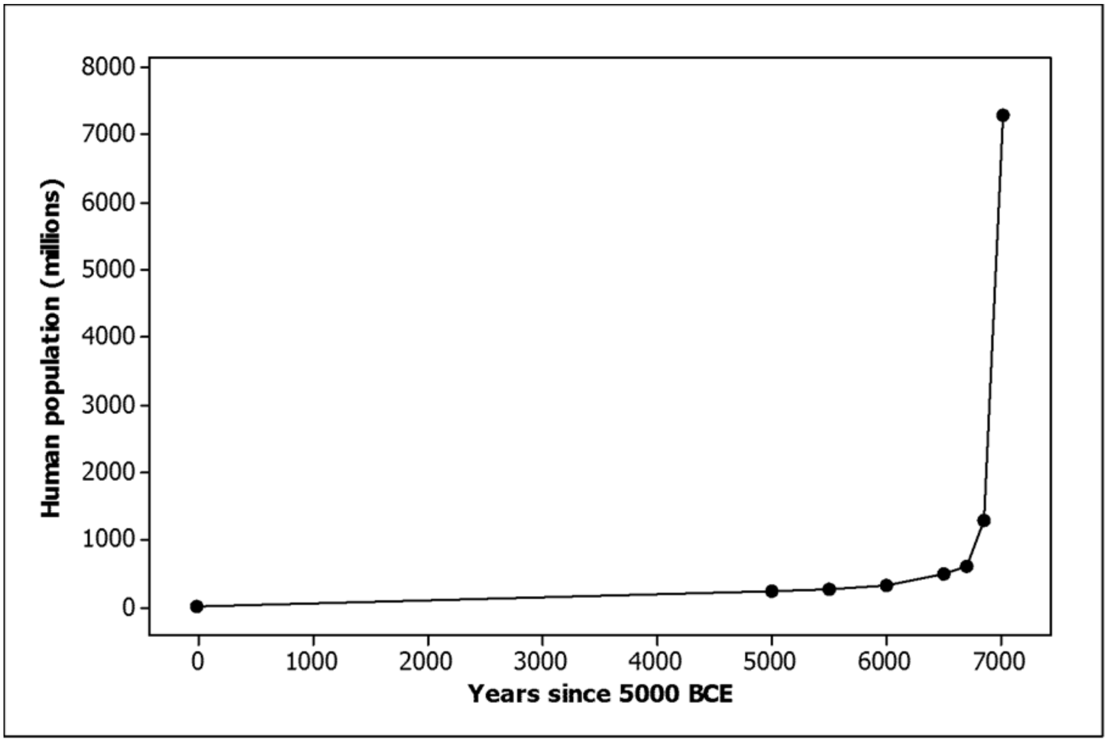

Fig. 4. Changes in the human population since 5000 BCE (data from Goldewijk et al. (2017))

to attain national targets that have gradually increased in many jurisdictions from 10% to 30% for the ecosystems that have been most attractive for land clearance, most notably grassy ecosystems and wetlands in the temprate zone, for the simple reason that these ecosystems are mostly gone.

The idea that national parks and other protected areas should be set aside from development in perpetuity has been honoured more in the breach than the observance in the less than one and a half centuries that they have been a recognised land use. The rate of environmental change is such that protected areas designed for one ecosystem may transition to another. This possibility has resulted in suggestions for increased connectivity of protected areas. when the evidence for the utility of connectivity at all but the longest time scales is scant (Kirkpatrick 2022). There have also been serious suggestions that protected areas need to be moved in space to counteract climate change. The implementation of this suggestion would obviously facilitate more deforestation and clearance and ignores the fact that protected areas are most of the remaining natural cover in a large proportion of countries.

15. Diet and Land Clearance

Human beings are physiologically omnivores, although we can prosper on a diet free of animals, if we are careful to consume enough vitamin B_{12}. The relevance of diet to land clearance is that it takes at least ten times less land or water to support a person on a plant-based diet than to support a pure carnivore, because the loss of energy in any trophic transfer (e.g. plant to herbivore or herbivore to carnivore) is 90 %. The recent explosion of land clearance in Brazil has been largely to grow soy beans to feed to cattle, which are then eaten by humans. A tendency towards more animals in the human diet would necessarily increase land clearance, with approximately a third of cropland dedicated to crops to feed animals in the early twenty-first century (Wirsenius et al. 2010).

Greenhouse Gases and Land Clearance

The realization that the business end of the hockey stick had arrived motivated some governments to encourage the substitution of renewable fuels for fossil fuels. Crops that could have fed humans were converted into alcohol for vehicle fuel. One of the biggest land clearance and deforestation events of the early twenty-first century has been the conversion of the tropical evergreen forests of Malaysia and Indonesia outside protected areas to oil palms, which are partly used to produce fuel, while a substantial proportion of the area devoted to maize in Brazil and the United States goes to the same end. The energetic balance of this crop conversion to fuel is likely to be such that it adds to the greenhouse gas burden, rather than reduce it once the removal of the original forest is taken into account. The proportion of cropland used for energy production has increased from 8.7% in 1995 to 11.7% in 2010 (Wirsenius et al. 2010).

16. Conclusions

The big history of clearance of our planet by humans is an exponential curve from the date of our first transition into agriculture (Fig. 3), with a few almost imperceptible blips in the middle of the flat part of the curve possibly relating to depopulation events, such as that which occurred after the European invasion of the Americas. Our even more exponential population growth (Fig. 4) has been a large part of the explanation for this explosion in clearance, as well as partly being a product of it, but our energy transition to fossil fuels underlay the explosion in both. In the late 20th and early 21st centuries clearance was partly fuelled by an increasing propensity for people to eat other animals that they fed on crop plants, rather than the plants themselves, and to use crops to produce liquid fuels.

The big history of deforestation began well before we transitioned into agriculture. A substantial recession of forests occurred as we used fire to increase the productivity of the landscape, eliminated much of the Pleistocene megafauna, and codeveloped a commensal relationship with *Canis familiaris*. Otherwise, forest loss responded to the same forces as land clearance, of which it was a substantial part.

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Structural Change in Big Economic History

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Abstract: Structural change is an important process that is much studied in economic history. Early studies include industrialization and the stadial theories of human activities. Biologists have adopted "economic" concepts of competition, cooperation and innovation to study the history of life in a broader sense. Extending the study of structural change over an even longer time frame is likely to require the adoption of new analytical frameworks. One possible approach is the computational-information-entropy-complexity framework. This could lead to a novel perspective that places economic history within a broader Big Economic History.

Keywords: Structural change, complexity

1. Introduction

Economists have long observed that the structure of economies undergoes distinct change over long periods. These long-term structural changes are characterised by how production, distribution and consumption activities are transformed over time, often driven by technological innovations. Such changes have been analysed in two ways. First, human society has evolved from hunter-gatherer to agrarian and finally to industrial economies. Second, a more recent approach has been to study economic transformation from agriculture to industry and services. These approaches have primarily focused on human economic activities and are, as such and by design, very much human-centred.

However, human existence is only a small portion of the broader canvas of big history that stretches back to the Big Bang, an event dating back to some 13.8 billion years ago (see **Table 1). Figure 1** provides a visual image of the differences in the time scale of various components of big history.

In studying economic activities across a longer time scale that includes pre-human existence (one that covers other species), it is necessary to frame economic history in a different way. Such a framework is built upon the idea that economics is a method that can be universally applied to study how living beings come into existence, interacts, survive, reproduce and evolve over time. This approach is not really novel because it has long been articulated by biologists (studying animal behaviour) and ecologists e.g. Noe et al (2001) and Vermeij (2004).

Table 1: Big History Timeline

Time	Event
13.7 billion years ago	Big Bang – Origin of Universe
4.5 billion years ago	Formation of the solar system, Earth, Sun
4 billion years ago	Emergence of Life on Earth
750 million years ago	Emergence of Animals (multicellular eukaryotes)
450-440 million years ago	Ordovician–Silurian extinction events
375-360 million years ago	Late Devonian extinction
252 million years ago	Permian–Triassic extinction event
201 million years ago	Triassic–Jurassic extinction event
85 million years ago	Divergence of apes from other mammals
5 - 7 million years ago	Emergence of first human ancestors
10,000 - 13.000 years ago	Domestication of plants and animals
12,000 years ago	Emergence of agriculture
1730-1840	Industrial revolution

Source: Christian (2011)

If the study of structural change is extended further back all the way to the Big Bang, it must necessarily use an entirely different approach built upon different metrics/variables that are more fundamental such as energy and information. One possible approach is to use complexity theory to explain the whole period of Big History.

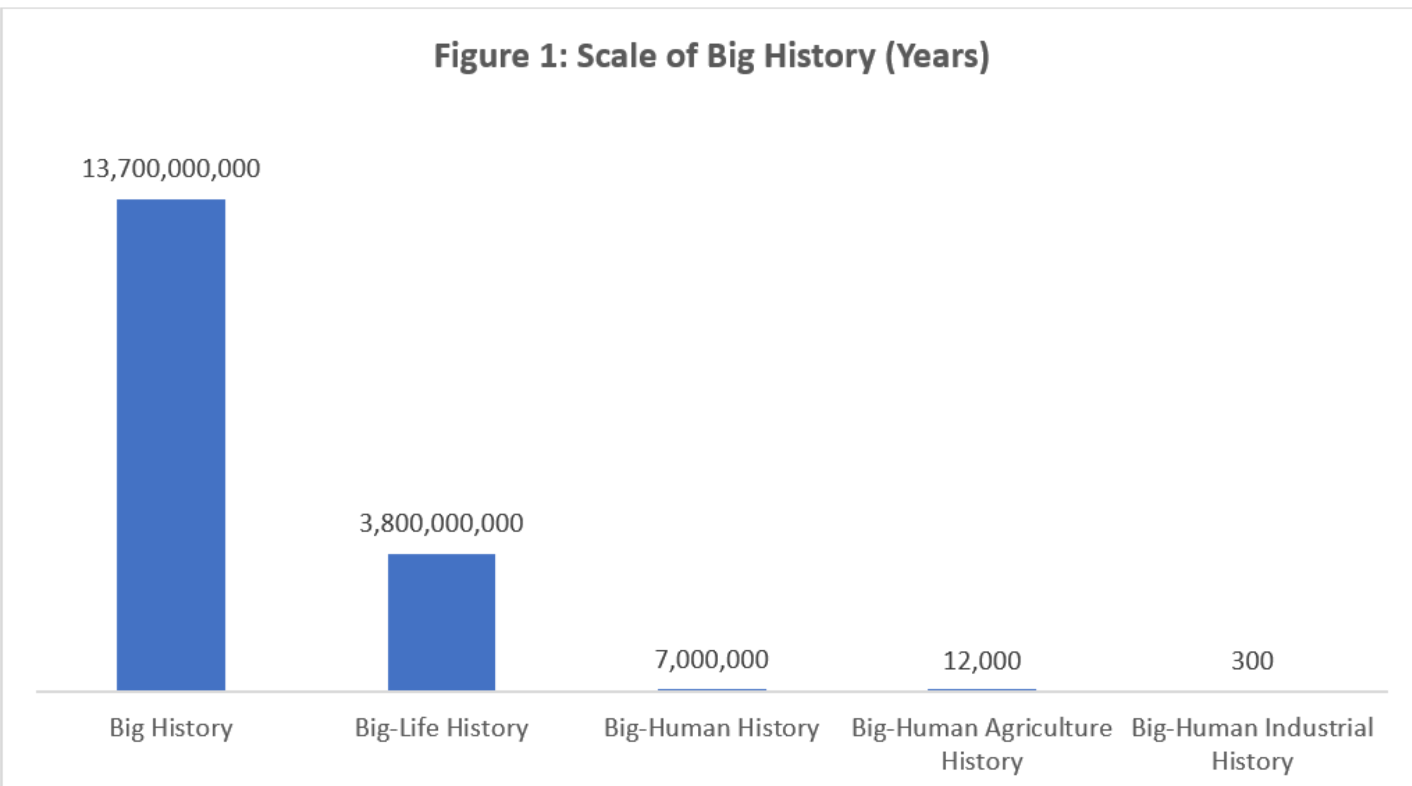
The goal of this essay is to reflect on all of the above issues. It begins in section 2 by surveying and synthesizing the existing literature on structural change in human-centred economics. It then extends it to include a broader framework of analysis that covers all living matter in Section 3. An attempt to sketch an even broader framework that covers the entire history of the universe is undertaken in Section 4. Section 5 concludes.

2. Structural Change in Economic History (Past 300 Years)

A common interpretation of the term 'economic structure' is the relative importance of different types of economic activities (or sectors) in an economy. Structural change or structural transformation refers to the reallocation of economic activity across three broad sectors of the economy, namely, primary (agriculture and mining), secondary (manufacturing and construction), and tertiary (services). A standard characterisation of structural change is to frame it in terms of changes in the relative importance of these sectors (Herrendorf et al., 2014).[1]

The study of economic structure and structural change at the sectoral level is not a recent endeavour. An early precursor was Quesnay's Tableau Économique (first published in 1758), which depicted the economy as comprising three classes, namely, the proprietary class (landlord), productive class (farmer and farm labourer) and sterile class (artisan and foreign merchant). The more 'modern' studies of economic structure and structural change date from the 1930s following the Great Depression. The early pioneering works focused on the development of data collection methods and tools such as national accounts (Simon Kuznets, Colin Clark, and Richard Stone) and input-output analysis (Wassily Leontief).

In the economics literature, the study of structural change usually focuses on two major phases of transformation



Source: Author

(**Figure 2**). In the industrialisation phase, there is a shift in the relative importance of economic activities (in terms of output and employment) from agriculture to manufacturing (Syrquin, 1988). Economic historians use the term "Industrial Revolution" to describe the industrial transformation beginning in Britain from the mid-18th century to the mid-19th century (Allen, 2017). Industrial revolution has been posited as a key factor in the "great divergence" between Europe and the rest of the world. The next phase of structural change which has been labelled "deindustrialization" occurs when developed economies began experiencing a reduction in the manufacturing share of economic activity. This is often accompanied by an increase in the share of services in economic activity.

The process of structural change is complex, involving many dimensions such as demand, technology, employment, factor accumulation, migration, location, demography, income distribution and the environment. The theories and empirics of structural change have focused on a number of drivers (Van Neuss, 2019). From a domestic demand perspective, a rise in per capita real income is accompanied by a decline in the share of food in final demand and an increase in producer goods, machinery and social overhead (Chenery and Syrquin, 1986). Not only is there an increase in the production of manufactured goods with greater income elasticity, but a higher proportion of these goods are intermediate goods – which leads to greater inter-sectoral interactions and dependencies. Sectoral change is also driven by changes in the prices of manufactured goods relative to agricultural goods – which is brought about by

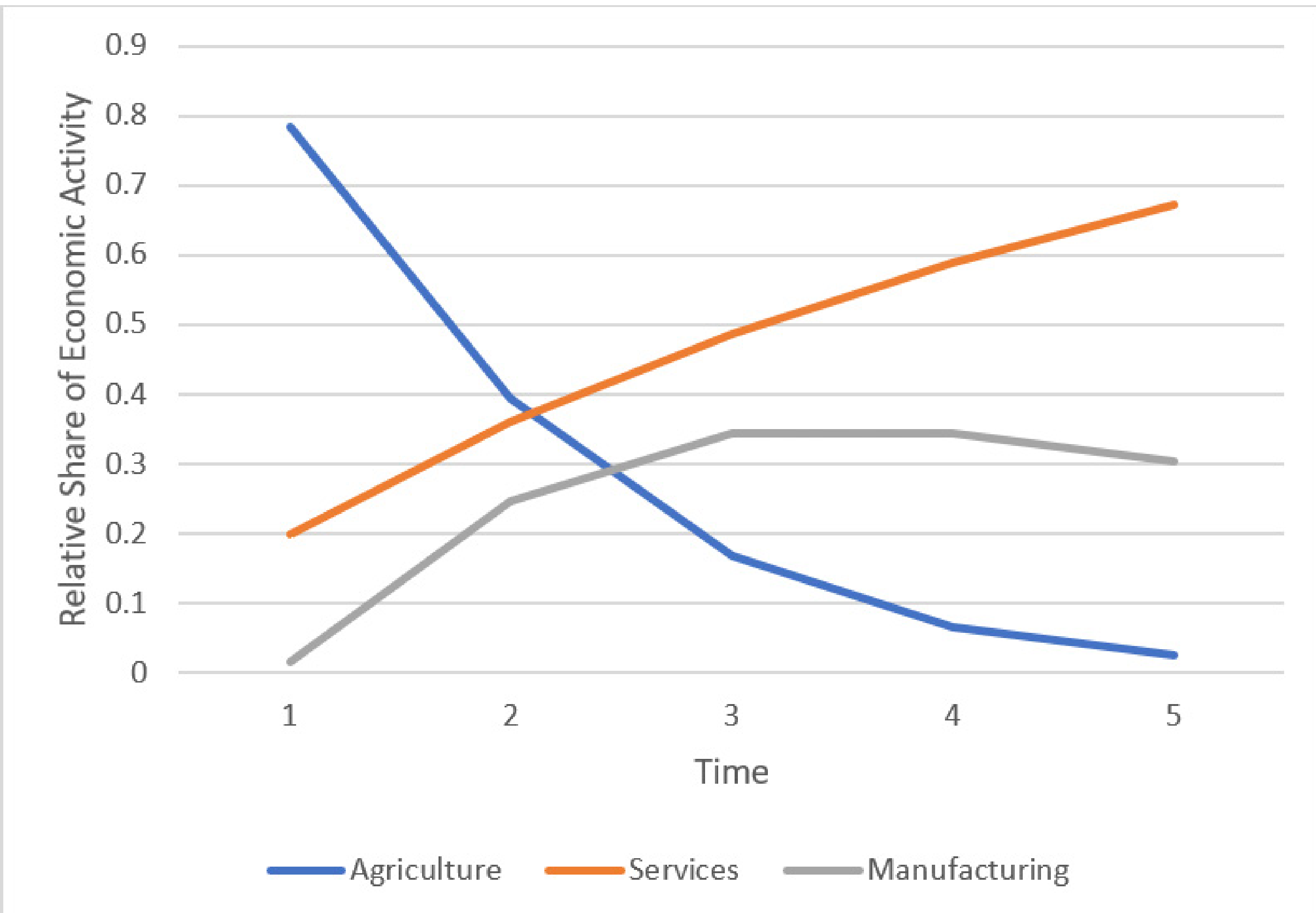


Fig. 2. Figure 2: Phases of Structural Change.
Source: Author

differences in productivity growth.

For many countries, especially smaller countries with a relatively lower endowment of natural resources, the rise in the trade of manufactured goods is another characteristic of industrialisation (Syrquin, 1988; Syrquin and Chenery, 1989). Recent empirical work has also emphasised the importance of country-specific technological factors (Eberhardt and Teal, 2012).

3. A Human-Centric Not-So-Big Economic History (Past 0.3 million years)

In the spirit of big history, the coverage of economic history is expanded further back – before industrial revolution – to essentially include the entire history of human existence. This is not entirely new to economic historians (Cameron and Neal, 2003 and White, 2018).

The split between the ancestors of humans and chimpanzees took place earlier, around 4-6 million years ago.[2] Humans, of the genus Homo, emerged around 2.5 million years ago (Belwood, 2022). The transformation brought about by the domestication of plants and animals took place around 10,000 to 13,000 years ago. Thus, for much of human existence, before the emergence of agriculture, humans lived as hunters and gatherers.

How have scholars theorized these different economic structures? These different economic structures have been the subject of analysis and theorizing as far back as the early 18th century. Theories of the different phases of dominant economic structures are known as "stadial theories" and "theories of four stages" (Schorr, 2018). Such theories influenced Adam Smith (1723-1790) who argued, notably in the *Wealth of Nations* and the *Lectures on Jurisprudence*, that there are four stages of structural change for societies, namely hunters (hunter-gatherer), shepherds (nomadic), agriculture, and commerce (industrial).[3] These stages are characterised by differences in production, consumption as well as stock and capital accumulation (**Table 2**). In earlier stages such as hunters and shepherds, labour is the main production input, and that production takes place with zero or minimal division of labour. Structural change in terms of transition from one stage to another is driven by population growth. Division of labour is more extensive in agriculture and reaches an advanced state in the commerce stage. It is the key driver of the transition from the agriculture stage to the commerce stage. This change is made possible with more extensive market exchanges and capital accumulation. Institutional dimensions such as property rights also become more important with the progression from the hunters stage to the commerce stage (Okun, 2017).

Another early and influential contribution on the study of long-term structural change comes from Thomas Robert Malthus (1766-1834). In Malthus's theory of population

Table 2: Adam Smith's Four Stages of Development

	Hunters	**Shepherds**	**Agriculture**	**Commerce**
Activity	Hunting and gathering	Pastorial, animal domestication	Agricultural	Manufacturing and services
Production Inputs	Labour	Labour	Labour, Land	Labour, Land, Capital
Division of Labour	Low number of occupations; High number of tasks per worker	Low number of occupations; High number of tasks per worker	Moderate number of occupations; moderate number of task per worker	High number of occupations; One task per worker
Extent of Market Exchange	Rare	Limited	Extensive	Extensive
Stock Accumulation	Zero	Moderate	High	High
Capital Accumulation	Zero	Zero	Moderate	Advanced
Drivers of stage transition	Population growth	Population growth	Population growth	Division of labour

Source: Author's compilation based on Okun (2017) any increase in the standard of living (income per capita) would bring about higher population growth that would eventually reduce the standard of living in the absence of (further) technological changes. Scholars have used the term "Malthusian Trap" to characterize the stagnation of economies in the period from 10,000 BC to the 18th century (dawn of the Industrial Revolution).[4] More contemporary works by Oded Galor and his collaborators have led to a "Unified Growth Theory" that explains the long-term structural change in terms of three regimes, namely, Malthusian, Post-Malthusian and Modern Growth (Galor and Weil, 1999, 2000 and Galor, 2011).

In the Malthusian Trap literature, the focus on income per capita or standard of living divides the entire human epoch into essentially two major phases, namely, a long period of Malthusian Trap characterised by economic stagnation and a shorter Post-Malthusian which began with the Industrial Revolution (**Table 3**). From a structural change perspective, the literature on the Malthusian Trap does not deny the existence of the four different stages discussed by Smith. This point is emphasized by Lloyd (2020). In a manner similar to Smith, Malthus discussed the existence four states – (i) savage or hunter state, (ii) shepherd state, (iii) state of mixed pasture and tillage, and (iv) commerce. The three early stages are embedded in the Malthusian Trap whilst the fourth "commerce" is post-Malthusian.

How did the transition from Malthusian Trap to Post-Malthusian occur? Galor and Weil (1999, 2000) and Galor (2011) provide explanations for the transition from one regime to another in the following manner:

- **Malthusian → Post-Malthusian**
  Population growth leads to larger population that, over time, induces higher technological change which, in turn, leads to higher income growth. This spurs further higher population growth. Per capita income continues to rise as output growth is higher than population growth. The rise in income per capita leads to an increase in fertility and a decline in mortality. As a result, both population and per capita income increase.
- **Post-Malthusian → Modern Growth**
  The increases in income growth and lower mortality provide incentives for reduction of fertility and investment in human capital. This leads to lower population growth. Greater human capital leads to higher technological change. As a result, population size (as well as average family size) decreases (demographic transition) and income per capita continue to increase.

The inter-dependence and transition between the different stages (path dependence) is also highlighted by Clark (2007) who argued that a precondition for the transition to productive capitalism is the existence of long periods of settled agrarian societies with strongly disciplined workers.

Another influential theory of long-term structural transition was articulated by Karl Marx (1818-1883) who also attempted to provide a historical analysis involving five stages (see Elster, 1986). The five stages do not correspond exactly to the stages of earlier stadial theories of the eighteenth century.

This is because the focus of Marx's theory is on the generation and distribution of value generated by labour and capital. In the first stage, economic activity comprises production for immediate consumption, resulting in no exchange or reinvestment. This could correspond to the most primitive version of the hunter and gatherer stage. Further comparisons break down. There is some surplus and exchange emerge in Marx's second stage. Trades become more established in the third stage following the generation of greater surplus (production for surplus). The

Table 3: Malthus and Regime Change

	Malthusian	Post-Malthusian	Modern Growth
Income Per Capita Growth	Constant	Slow	Steady
Relationship between income per capita and population growth rate	Positive	Positive	Negative
Technological Change	Slow	Slow	Steady

Source: Galor and Weil (1993)

fourth stage and the fifth stage are characterised by the emergence of the internal market and money, respectively. In the fifth stage, production is driven by the pressure to generate surplus. Pastoral and agrarian societies seem to have some features of Marx's second and third stage, and possibly even the fourth stage (internal market). Both agrarian and capitalist societies are likely to use money, hence, are part of the fifth stage. The notion of subsistence (which appears in the stadial and Malthusian theories) also appear on Marx's analysis – wages in capitalist systems are driven to subsistence levels. Conflict over distribution of surplus value produced is a key feature of Marx's theory. Conflicts such as wars are featured in Malthusian theory differently – as positive checks on population growth.

More recent works such as North *et al* (2009) also emphasized the institutional mitigation of conflict or violence in human history through social orders. The authors argue that human history is characterised by three types of social orders, namely, foraging order, limited access order and open access order. Limited access order (also known as natural state) is characterised by social organizations based on personal relationships. In open access order, social organizations become increasingly accessible to individuals who met a minimal set of impersonal criteria. The three social orders differ in terms of the governance of societies and the importance of individual identities in social interactions. As we move from foraging order to limited access order and finally, open access order, personal relationships become less important in economic interactions. Placing the four stages discussed earlier within these three categories is not a straightforward exercise. The hunter-gatherer is foraging order and the pastoral and agrarian could be limited access order. The commerce/industrial stage is an open access order where impersonal markets thrive. The social order framework provides another dimension to analysing structural change – one embedded in institutions and conflict.

The theorizing of human-centric economic history is inexhaustible and not likely to converge to a single explanation. The above review of stadial theories provide some flavour of how economists have attempted to make sense of structural change within the long duration of human existence. Existing theories clearly do not spend enough time on the hunter-gatherer societies in the structural change story. Perhaps this is due to the focus on history driven by written records. The challenge is even greater if the time coverage is expanded further to include the emergence of all forms of life. This is explored next.

4. Big Life Economic History (Past 4 billion years)

Life in the form of a simple microbe, protocell, first emerged on earth some 4 billion years ago. This microbe is the sole shared ancestor of all life forms on earth (with the exception of possibly, virus). Over time, new life forms emerged. Two billion years after protocells emerged, simple microbes evolved into complex cells with nucleus. Mitochrondia, which powers multi-cellular cells, emerged two billion years ago. Chloroplast appeared about 1.5 billion years ago, paving the way for the emergence of plants about one billion years ago.

The earliest ancestor of animals first came into existence some 750 million years ago. Animals subsequently evolved in different complex life forms – fish (600 MYA), insects (480 MYA), mammals (310 MYA), dinosaurs (230 MYA) and primates (56 MYA).

Economists generally do not study the emergence and evolution of life on earth. If the study of economic history is to be extended before human existence, a new framework of analysis is needed. In a human-centric economic history, *Homo Sapiens* is the central economic agent and this economic agent is assumed to be remain relatively unchanged over time biologically (but perhaps not culturally). If the relevant time span is expanded to cover all life since their beginning, the focus of analysis is shifted to cover the different types of life forms.

Returning to the issue of structural change, what exactly is being transformed over time in Big History? In the human-centric approach, the focus is on different type of economic activities. Across the different life forms, it is perhaps more meaningful to frame "economic activities" in terms of how living organisms carry on activities that sustain life in terms of both survival and reproduction. This is not entirely novel, as biologists have modelled non-human animal behaviour in terms of optimization strategies – which is a key feature of economics (Noe et al, 2001). Others have focused on demand-side explanations based on individual-level strategic pursuits (Snooks, 2008).

Economists too have acknowledged the kinship between economics and biology from this perspective (Hirshleifer 1985 and Hodgson 1993). This kinship is premised on shared emphasis on competition, cooperation, specialization, innovation (random mutation), and evolution (Hirschleifer, 1985). Biologists such as Vermeij (2004) have also proposed an economic history of nature based on these perspectives on the role of competition and cooperation in nature.

How should the history of structural change be analyzed from a natural economy perspective? First, the time dimension, over which changes take place, can be very long indeed especially when evolution through natural selection is the driver of change. Within the process of evolution, competition and cooperation take place at both intra and inter species levels. Structural changes occur when there are changes in the ways in which living organisms compete and cooperate in nature. This would include major transitions associated with the emergence of new species.

Within this interpretation, evolution can be seen as a process of structural change. This process is subject to random shocks in terms of mutation and genetic drift. The latter could be driven by climate change and extinction-level events, for example, caused by large asteroids. The mass extinction of dinosaurs 66 million years ago is an example of the latter.

The above discussions lead to the question of whether there is a meaningful way to distinctively classify the different phases/stages of life history on earth. The emergence of new species leads to large-scale changes in the nature of competition and cooperation within ecosystems. One possible way to examine this is in terms of how evolution affects the structure of food web (Eklöf et al, 2012). Each key event, which is related to the emergence of new animals or the extinction of animals, could be considered to be a key phase of structural change. An even more fundamental transformation could be the emergence of genetic materials as a key hardware for evolution. But these may not necessarily be the most important stages for at least two reasons.[5] First, multicellular organisms only emerged 600 million years ago – a mere 15 percent of the entire timespan of life on earth. Second, as the emergence and evolution of life forms are sequential, the earliest ancestors are important.

Finally, much of the literature on the emergence and evolution of life points to complexity of biological systems (Zimmer, 2013). What is a complex system? Mitchell (2009, p.13) defines a complex system as “a system in which large networks of components with no central control and simple rules of operation give rise to complex collective behaviour, sophisticated information processing, and adaptation via learning or evolution”. An important concept in complexity theory is emergence defined as the formation of global patterns that arise from local interactions.

One appeal of complexity theory is its usefulness in studying an extensive range of phenomena from biology to economics. For example, in biology, scholars have examined whether evolution increases the complexity of life forms. This topic remains much-debated and contentious. In economics, complexity theory is used to model various economic phenomena such as cities, traffic and business cycles (Hildalgo, 2021). Aside from scope, the wide range of application of complexity theory provides a framework to analyse structural change over a very long range of time. The notion and modelling of structural change could take on a different meaning within the complexity theory perspective.

5. Is A Truly Big Economic History Possible? (13.8 billion years)

The literature on Big History covers the entire existence of the universe, starting from the Big Bang which took place some 13.8 billion years ago. The time period with lifeforms on earth (4 billion years) accounts for only 29 percent of the time period since the Big Bang. Any attempt at constructing an economic history that covers pre-life-on-earth time period is very challenging. To set up the context for discussions on this topic, it is perhaps useful to review what is known about Big Bang and the history since this event (up until the emergence of life). The analysis of the pre-life period since the Big Bang is entirely in the domain of physics. Based on the narrative provided by Kinney (2022) and Christian (2004), the very short and early period immediately after Big Bang, which amounted to less than 3 seconds, is characterised by the emergence and transformations of the basic building blocks of the universe (**Table 4**). This is brought about by changes in the operations of different fundamental laws of nature (physics) – strong force, electromagnetic force and gravity. As the universe cooled, density declined and space inflated. Clearly, this portion of big history involves several phases of structural change (using the term in the widest sense) that ultimately led to the large-scale structure of the universe as it is observed by us today.

At this point, it is difficult to see how economic

Table 4: Key Events After Big Bang

Time after Big Bang	Significant Events
$t = 10^{-43}$ seconds	**"Planck Era"** • Universe is smaller than the "Planck length" - the smallest length that has any physical meaning • Physics unknown
$t = 10^{-34}$ seconds	**Grand Unified Theory/Symmetry Breaking / Energy Scale of Inflation** • Phase transition takes place where strong nuclear force is separated from the weak and electromagnetic forces • Creation of asymmetry between matter and antimatter
10^{-34} sec $< t < 10^{-12}$ sec	**Unknown** • Inflation - universe expands faster than the speed of light and cools to near absolute zero
10^{-12} sec $< t < 10^{16}$ seconds	**Higgs Instability / Electroweak Phase Transition** • Higgs boson becomes unstable around $t = 10^{-12}$ sec • Universe is a dense primordial soup comprising free quarks, leptons, force carriers (gluons, W and Z bosons and photons) and antimatter counterparts • Formation of dark matter
$t = 10^{-6}$	**Quark/Hadron Phase** • Free quarks and gluons condense into protons and neutrons
t = 1 seconds	**Primordial Nucleosynthesis** • Proton and neutrons condense into atomic nuclei • Neutrinos decouple from thermal equilibrium • Electrons and positron annihilate into photons
t = 60,000 years	**End of Radiation** • Dark matter decoupled from cosmic plasma and collapse into bound structures
t = 300,000 years	**Recombination** • Nuclei and free electrons condensed into neutral hydrogen and helium gas • Universe becomes electrically neutral
t = 1 billion years	**End of Dark Ages** • Emergence of first stars and galaxies
t = 6 billion years	**Onset of Cosmic Acceleration** • Dark energy causes expansion of universe

Source: Author's compilation based on Kinney (2022) and Christian (2004) history can be related to the Big Bang and the subsequent transformation of the universe up to a point before the emergence of life. This difficulty arises from the lack of a useful framework within more conventional economic history that could be extended to analyses of wider time frame. Interactions between various types of forces occur but not in the sense of "competition" and "cooperation" that underpins economic analysis.

New notions and concepts that traverse a wider time frame are needed. Four interrelated concepts come to mind – computation, information, entropy and complexity (Mitchell, 2009). Lloyd (2006) provides a narrative of the history of the universe since Big Bang from a computational (information processing) perspective. Big Bang is a maximum entropy event with zero information (entropy and information are two opposite sides of the same coin). As the universe cools downs and expands, entropy decreases, and the amount of information (processing) increases. The subsequent emergence and evolution of life can also be couched in terms of increasing complexity (information) over time (see Davies and Gregersen, 2010; Lineweaver, 2013; Walker et al, 2017).

The next step is to use the same computational-information-entropy-complexity approach to frame structural change in the human-centric (economic) history. Scholars such as Hildalgo (2015, 2021), Hildalgo et al (2007) and Haussman et al (2013) have already attempted to re-cast economics in terms of complexity. Haussman et al (2013, p.18) describes complex economies as "those that can weave vast quantities of relevant knowledge together, across large networks of people, to generate a diverse mix of knowledge-intensive products". The authors go on to construct an index to measure product complexity that is based two notions – diversity (in product space) and ubiquity (in country space). Theoretically, it might be possible to construct a human-centric economic history based on structural change that is measured in terms of product complexity.

One aspect of complexity that is worth examining is the increase in the interactions, linkages and interdependence between individuals, groups and societies across time and space. Globalisation is a manifestation of this phenomenon which has a prominent place in both history (McNeill and McNeill, 2003) and economic history (Allen, 2011 and White, 2018). Technological change is a key driver of globalization which has many dimensions such as social, economic, cultural and political. Sachs (2020) has proposed the classification of the history of human-centered globalization into seven ages (see **Table 5**). Re-framing these seven ages in terms of complexity theory

Globalization Age	Approx. Dates	Primary Energy	Information Media	Agriculture	Industry
Paleolithic	70,000-10,000 BCE	Human, ocean currents	Language, petroglyphs	Hunting, gathering	Stone tools
Neolithic	10,000-3,000 BCE	Oxen	Hieroglyphs	Crops, animal husbandry	Bronze, copper
Equestrian	3,000-1,000 BCE	Horse	Early writing system, stela	Plow	Iron, wheel cart
Classical	1,000 BCE – 1,500 CE	Windmill, waterwheel	Alphabet, book	Large-scale grain trade	Engineering, infrastructure
Ocean	1500 – 1800	Ocean, wind	Printing press	Global trade of crops	Ocean navigation
Industrial	1800 – 2000	Fossil fuels hydroelectric	Telegraph, telephone, broadcasting	Chemical fertilizers	Stem engine, textile, steel
Digital	2000 -	Solar, wind	Internet, artificial intelligence	Precision agriculture	Digital nerworks

Table 5: Sachs's (2020) Nine Ages of Globalization Source: Table 1.1, p.6 in Sachs (2021)

entails paying attention to the transformations in terms of changes in information and information processing which is also linked to energy production and utilisation. Each of these changes are covered by existing studies separately, for example, information (code) by Auerswald (2017) and energy by Smil (2017, 2021). The various branches of the relevant literature needs to be synthesized into a more holistic and open framework based on the computational-information-entropy-complexity approach.

6. Conclusions

The essay began with a modest attempt at reviewing the various notions and theories of structural change in economics and economic history. In contrast, the current notion of big history is one that covers a much broader time dimension – the entire existence of the universe. This goes further back than what economists have traditionally covered. Biologists have adopted "economic" concepts of competition, cooperation and innovation to study the history of life in a broader sense.

As we attempt to go back further in time, the frameworks of analyses need to be changed to accommodate a broader range of phenomena. An underpinning assumption underlying such an endeavour is that it is possible to have a universal approach to big history. In such an approach, the existing interpretation of economic history need to be entirely re-framed. The computational-information-complexity approach is one plausible way to do this. This could lead to a novel perspective that places economic history within a broader Big Economic History.[6]

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Endnotes

1 Economic historians often study structural changes at a more disaggregated level such as within sectors, industries, firms and households.
2 Source: https://www.science.org/content/article/generation-gaps-suggest-ancient-human-ape-split#:~:text=For%20the%20past%2045%20years,to%209%20million%20years%20ago.
3 Reid (1989) attempts to reconstruct Adam Smith's four stages of history in a deterministic growth trajectory. However, the coherence of Smith's work on the four stages is called into question by Paganelli (2002).
4 There are disagreements amongst economic historians about the great divergence and the Malthusian trap. For example, there is empirical evidence supporting "little divergence" in which the economic gravity shifted away from Asia and Southern Europe towards northern Europe between 1300 and 1800. The author thanks one of the anonymous reviewer for pointing this out.
5 It might also be useful to think about the difference between self-replication and self-reproduction.
6 However, it is possible that approach may not necessarily appeal to economic historians who would argue that economic history does not have anything useful to say about life before humanity and that the computational-information-complexity approach could be focusing more on new (e.g. mathematical) methods. The author thanks an anonymous reviewer for this point.

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Dos Perspectivas Teóricas para Explicar la Gran Historia: Fred Spier & Pedro Ortiz Cabanillas

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RESUMEN

Introducción

La hipótesis central de esta investigación es que actualmente existen dos propuestas teóricas dentro de la Gran Historia: la propuesta declarada y reconocida mundialmente de Fred Spier y la propuesta desconocida de Pedro Ortiz Cabanillas implícitamente contenida en su Teoría Sociobiológica Informacional.

Métodos

Se procederá a sintetizar y presentar las dos propuestas teóricas de Gran Historia de Spier y de Ortiz, comparándolas e identificando puntos de contacto y diferencias.

Resultados

La propuesta teórica de Spier, sintéticamente, presenta el devenir del universo en tres momentos: cosmológico, biológico y social; siendo la base epistemológica una teoría cualitativa de la complejidad. La propuesta de Ortiz (sobre la base de una teoría cualitativa de la información) presenta el devenir del universo en seis niveles de complejidad. De modo paralelo tendríamos: el nivel 0 (el momento cosmológico de Spier); el nivel uno, dos, tres y cuatro (el nivel biológico de Spier); y el nivel 5 (el momento social de Spier). Existen diferencias puntuales entre ambos planteamientos, pero más son las articulaciones y puntos de contacto.

Conclusiones

La hipótesis de esta investigación es correcta: tanto Spier (explícitamente) como Ortiz (implícitamente) tienen teorías explicativas de la Gran Historia. Aun cuando Spier y Ortiz nunca tuvieron contacto (ni personal ni académico), sus teorías se articulan en un mismo esquema explicativo y se nutren epistemológicamente de modo simultaneo. La Gran Historia se fortalece a partir de lo que aquí se devela.

Palabras clave:

Información, Complejidad, Macrohistoria, Régimen, Sistema

INTRODUCCIÓN

Los autores de la Gran Historia (originalmente, *Big History*, y también llamada *Macrohistoria*) enfocan la historia humana en el contexto amplio de la historia cósmica: desde el comienzo del universo hasta el momento actual (Hesketh, 2014). Así, la pretensión de la Gran Historia es la explicación o comprensión de la totalidad del universo (Spier, 2005). Para ello, la Gran Historia integra y sintetiza los estudios relacionados con el pasado, pero desde una perspectiva novedosa y coherente que proviene, entre otras ciencias, de la astronomía, geología, biología, antropología (Christian, 2008). La Gran Historia es un campo relativamente nuevo de conocimiento y publicaciones que recoge a una miríada de autores (Vélez, 1994; Gamero-Valdivia, 1999; Christian, 2004; Harari, 2011, 2016, 2018) que muestran una coincidencia histórica global en el afán de explicación desde una visión totalizadora (Conrad, 2017; McNeill & McNeill, 2004). Es importante señalar la creación de los proyectos Gran Historia por Bill Gates y David Christian; luego, la *International Big History Association* en agosto de 2010, y más adelante, la creación de la *Red Europea de la Gran Historia* en setiembre de 2017.

De manera general, pero sintética, se pueden agrupar en dos las explicaciones (y las posiciones de los autores) dentro de la Gran Historia. Por un lado, tenemos a los autores que hacen *storytelling* al momento de exponer su enfoque de Gran Historia sobre la base de unos hitos específicamente seleccionados. Por otro lado, tenemos a los autores que hacen *teoría* al momento de explicar la Gran Historia. Un ejemplo puede resultar esclarecedor, si asumimos que las moléculas de agua se mueven azarosamente en los océanos, entonces el trabajo del Gran Historiador (con perspectiva teórica) consiste en identificar corrientes marinas, olas, tsunamis, etcétera. En específico, la Gran Historia nació de la mano del primer enfoque (storytelling), y es en el primer enfoque donde más ha reverberado y reverbera esta disciplina en la actualidad (Villmoare, 2023). Del segundo enfoque (teoría) al momento de explicar la Gran Historia tenemos, hasta donde alcanza el saber de los autores, solamente un caso: Fred Spier (Spier, 1996, 2011, 2023).

Cuando se hace teoría en Gran Historia, es la teoría la que guía la explicación. Una teoría se evidencia por detrás (o por dentro, o por debajo) de los hitos históricos. Una teoría explica, articula, presenta, organiza, es decir: teoriza (valga la redundancia) los hitos históricos. Ahora, tratándose la Gran Historia de la historia del universo, entonces una teoría de Gran Historia será siempre una teoría del universo (es decir, una teoría que explica, o que busca explicar, la totalidad). Esta totalidad está reflejada en la natural transdisciplinariedad que suscita la Gran Historia. En este sentido, una teoría de Gran Historia es una suerte de macroteoría que incluiría en sí misma: una teoría cosmológica, una teoría biológica y una teoría sociológica como mínimo. Una explicación de este tipo, necesariamente, tiene o debe tener un enfoque de sistemas complejos, y permite (o debe permitir) resolver fenómenos complejos. Es por todas estas implicancias que hacer teoría en la Gran Historia resulta especialmente desafiante, por lo que es aún más valioso y original el esfuerzo emprendido por Fred Spier.

Fred Spier estudió bioquímica, antropología cultural e historia social en Holanda a fines de los años ochenta. Esto le permitió estudiar la religión y la política en Perú, centrándose particularmente en una aldea rural, la de la parroquia de San Nicolás de Bari, en el distrito de Zurite, Cuzco. Fred Spier estudia la Gran Historia desde una perspectiva teorética, es decir, hace teoría, o también: usa una teoría (su propia teoría). Según señala el propio autor, en 1996 publicó el libro *The Structure of Big History* en donde esboza su teoría de la Gran Historia en términos de "regímenes" (un equivalente interdisciplinariamente más adecuado que el concepto tradicional de "sistema") (Spier, 1996, 2023). Dentro de las fuentes de las que se nutre la visión de Spier se encuentran, entre otros, las reflexiones del astrofísico Eric Chaisson (Chaison, 2001) y Erich Jantsch (Jantsch, 1980). Spier publicó *Big History and the Future of Humanity* (Spier, 2010), libro que sintetiza y declara de modo formal su teoría de la Gran Historia, develando a la Gran Historia como un campo interdisciplinario (Spier, 2008).

Ahora bien, en el Perú, desde la década de los 80 del siglo pasado, se gestó un caso genuino de creación teórica. El peruano que hizo esto fue: Pedro Ortiz Cabanillas (1933-2011). Entre los años 1984 y 1994, Ortiz concibió una explicación sociobiológica del universo, y entre los años 1994 y 2011, desplegó una teoría general de la información que, *grosso modo*, permite explicar cómo se relacionan (cómo se integran y organizan) el universo, la sociedad, la persona, el cuerpo en general, y el sistema nervioso en particular (Ortiz, 1994, 1997, 2004, 2010). Ortiz es conocido como uno de los neurólogos más prominentes, quizá el mayor de todos, dentro de la tradición médica peruana (Contreras Pulache et al., 2019; Contreras Pulache et al., 2018).

Por otro lado, no hay ningún documento ni cita ni referencia que haga considerar que Ortiz tenía conocimiento del concepto/disciplina/palabra "Gran Historia". Sin embargo, es evidente que la teoría de Ortiz tiene implícita una Gran Historia. Si esta Gran Historia *implícita*, se hace *explícita*, si se la devela: se habrá revelado un segundo enfoque teórico de Gran Historia.

En este documento se pondrán en diálogo dos enfoques teóricos de Gran Historia. Uno, el de Fred Spier, declarado expresamente y reconocido institucionalmente en los estudios de Gran Historia. Y dos, el enfoque de Gran Historia que implícitamente se encuentra en la teoría de Pedro Ortiz Cabanillas (y que, esta publicación, se encargará de explicitar por vez primera).

METODOLOGÍA

Estudio de tipo cualitativo, bibliográfico, con enfoque teórico orientado a la delimitación y análisis de los planteamientos de Fred Spier (1952-) y Pedro Ortiz Cabanillas (1933-2011). Respecto al material de investigación, en el caso de Fred Spier se utilizó su libro *Big History and the Future of Humanity* (Spier, 2010); mientras que, en el caso de Pedro Ortiz, se tomó en cuenta su libro *Introducción a una Psicobiología del Hombre* (Ortiz, 2010).

El libro *Big History and the Future of Humanity* recopila la propuesta teórica de Fred Spier en relación con la Gran Historia. En 1996, el autor presentó una versión preliminar de su planteamiento en el libro *The Structure of Big History* (Spier, 1996). Durante el periodo comprendido entre 1996 y 2005, Spier expuso su teoría en importantes centros de investigación (como el Instituto Santa Fe, entre otros), estas experiencias le permitieron darle forma definitiva a su propuesta. Además, en la Universidad de Amsterdam, Spier creó la Cátedra de Big History, que hoy en día es un modelo de enseñanza global de Big History, como lo demuestra su adaptación a los medios digitales masivos, incluyendo el curso digital de Big History en la plataforma de educación digital Coursera. Según el propio Fred Spier, su obra *Big History and the Future of Humanity* resume toda la experiencia acumulada entre 1996 y 2005, presentando su propuesta teórica final sobre la Gran Historia. Dicha obra cuenta con ocho capítulos en los cuales el autor busca una explicación del mundo actual, partiendo del Big Bang como origen del universo. Así, toma en cuenta la definición de términos claves como complejidad, materia, energía, regímenes, condiciones goldilocks, entre otros, así como el desarrollo de aspectos centrales, como la evolución del cosmos, el surgimiento de la vida, la aparición del cerebro y la conciencia, la historia primitiva y la historia humana, los estados, la globalización, la industrialización, incluyendo una visión del futuro de la humanidad en función al estado de los recursos terrestres.

El libro, en su segunda edición, *Introducción a una Psicobiología del Hombre*, de Pedro Ortiz Cabanillas, consta de siete capítulos en los que el autor expone su Teoría Sociobiológica Informacional que busca la explicación del universo, relacionando este con la sociedad en general y el sistema nervioso en particular, exponiendo y desarrollando temas como los niveles de organización de la vida y los tipos de información relacionados, la determinación epigenética y cinética de los sistemas vivos, ofreciendo una definición genuina de la información (una teoría general de la información) y del individuo como personalidad. El esfuerzo emprendido por Ortiz desde 1980 hasta el 2011 estuvo enteramente centrado en elaborar un examen clínico de un paciente (esto queda claro en 1980 cuando declara públicamente su proyecto de investigación), sin embargo, hacia 1984, Ortiz cayó en cuenta de necesitar una teoría del universo que sea el marco general para desarrollar su método clínico. En este sentido, Ortiz no está elaborando explícitamente una teoría (por lo menos no fue su intención original) sino que deviene en una teoría como condición necesaria para su propio fin: contar con un modo explicativo de cómo son las personas por dentro, y por tanto explicar sus procesos de salud y enfermedad a través de un examen clínico original y único. El método clínico de Ortiz replantea las formas tradicionales de enfocar a un paciente y representa uno de esos esfuerzos (aún sin continuación) por desarrollar una nueva medicina humana (ya a nivel explicativo, de procedimientos y de diagnósticos).

Ambos libros fueron sometidos a una lectura atenta y dirigida a identificar, primero, las propuestas teóricas explícitamente o implícitamente planteadas por los autores en torno a la Gran Historia; y segundo, detallar los hitos cronológicos más importantes que cada una de las teorías propone. Se elaboraron para este fin fichas bibliográficas y esquemas comparativos. Posteriormente, se realizó un programa académico de 30 horas de clase sincrónica distribuidas a lo largo de 10 sesiones y en donde se siguió un esquema general de Club de Lectura denominado "La Sociobiología Informacional de Pedro Ortiz Cabanillas como Gran Historia", realizado durante el verano 2023 en Lima-Perú, conducido por uno de los que aquí escriben (HCP). En estas sesiones académicas se procedió a realizar una lectura crítica de fragmentos seleccionados de ambos libros y a realizar su respectivo comentario, comparación y crítica. Participaron en estas sesiones un total de 10 profesionales de distintos perfiles (medicina, psicología, educación, filosofía, historia y otras ciencias sociales); todos los autores de esta publicación formaron parte de ese grupo. Adicionalmente, se contó con la valiosa orientación de Fred Spier, quien estuvo presto a absolver, con una comunicación fluida vía correo electrónico, las dudas surgidas en torno al estudio de su obra y a la realización del presente trabajo.

Para operativizar la presentación y el análisis de las propuestas teóricas, se consideró la descripción de las siguientes dimensiones:

- *El todo de la Gran Historia*: que hace referencia a cómo se concibe la "totalidad" en cada una de las propuestas teóricas de los autores.
- *Estrategias metodológicas*: relacionada a las herramientas y métodos que siguen los autores en el proceso de exposición y elaboración de sus teorías.
- *Explicación de la complejidad*: que hace referencia a la explicación de complejidad que se presenta dentro de la explicación teórica. Tanto Ortiz como Spier elaboran teorías que explican la complejidad (Spier lo declara explícitamente; Ortiz usa el término "información" para explicar la complejidad de los sistemas vivos; por lo mismo, también tiene implícitamente una explicación de la complejidad). Justamente el despliegue de esta complejidad constituye, en ambos, el devenir de la Gran Historia. La complejidad es el ámbito de contacto que permite articular a Spier y Ortiz.
- *Denominación*: referida al nombre que le asigna cada autor en su exposición.
- *Justificación*: que hace referencia a los motivos que expone cada autor para con la meta o justificación de su teoría.

Finalmente, siguiendo la exposición de ambos autores, se ha procedido a especificar los Hitos de la Gran Historia, que explícita o implícitamente presentan tanto Fred Spier como Pedro Ortiz Cabanillas. Se han elaborado tablas informativas para presentar los resultados.

RESULTADOS

La Tabla 1 muestra los rasgos de la teoría de Fred Spier en torno a la Gran Historia. Esta Gran Historia se sucede en 3 momentos de complejidad: antes de la vida (1), con la vida (2), y con la presencia de los hombres (3). La totalidad de Spier es la totalidad cosmológica; luego, la totalidad de la vida; y finalmente, la totalidad de las personas y la sociedad. Principia con un Big Bang y recorre toda la historia del universo.

La Tabla 2 muestra los rasgos de la teoría de Pedro Ortiz Cabanillas en torno a la Gran Historia, implícitamente planteada en el desarrollo de sus ideas. Se precisa lo siguiente: aun cuando nunca lo haya expresado en estos términos, Ortiz tiene una teoría de Gran Historia, y lo que llamaríamos la totalidad de Ortiz, está alineada en 6 niveles, siendo el Nivel 0 el que corresponde a la edad del universo antes de la presencia de la vida. La complejidad que explica Ortiz sería (y con mucho detalle) la complejidad interna de todos los seres vivos. En este sentido, despliega 5 niveles informacionales de complejidad. La Sociedad es el quinto nivel, e incluye a las personas.

Ambos autores coinciden en el método. Para Spier, iniciar por el Universo es empezar por lo que está más arriba. Para Ortiz, empezar por el universo es empezar por lo que está más atrás. Ambos aspiran a cubrir la totalidad de los fenómenos, mostrando un mismo enfoque que va del todo a las partes (y no al revés). Lo que Spier llama nivel de complejidad 1 (la historia antes de la presencia de los seres vivos) constituye el Nivel 0 de Ortiz. El despliegue cosmológico de Spier no tiene comparación con Ortiz. La teoría de Ortiz no tiene interés en lo cosmológico sino en lo filosófico natural. Por otra parte, lo que Spier considera como tercer nivel de complejidad es para Ortiz el quinto nivel de complejidad informacional. Aquí, podría decirse que ambas teorías se mueven bajo una misma sinfonía. En este sentido, el segundo nivel de complejidad de Spier es explicado por Ortiz en 4 oleadas de detalle que expanden y profundizan el horizonte de Spier. Y finalmente, la tercera complejidad de Spier es expuesta por Ortiz como parte de la emergencia de la quinta complejidad informacional: la explicación de los cinco niveles de organización interna de una persona, por un lado; y, por otro lado, la explicación de la "información social". En cuanto al futuro de la Gran Historia, el único que ha estudiado ello es Spier; Ortiz no

Tabla 1. Caracterización de la teoría de Fred Spier

El todo de la Gran historia	El todo es la extensión que va desde el origen del universo (Big Bang) hasta la actualidad. Presenta una posición que asume un Big Bang.
Estrategias metodológicas	Perspectiva: holística. La Gran Historia intenta hacer un mapa de conocimientos de todo el pasado. Usa el método científico del todo a las partes. Su descripción es de arriba hacia abajo: desde las partículas subatómicas del universo hacia la galaxia, el sistema solar, la tierra, la vida, la cultura.
Explicación de la complejidad	Intercambia el término "régimen" con el de complejidad. Concibe tres niveles generales de complejidad: 1. El de la naturaleza físicamente inanimada. Materia no viva. Materia Cósmica. Etapa prebiológica. No existen centros de Información. 2. El de la vida. El centro de información está en el ADN. La vida se sostiene hacienda acopio de materia y energía. 3. El de la cultura. Es la información almacenada en los nervios y en las células cerebrales de los seres humanos. Un régimen es más complejo cuanto más numerosas y variadas sean las conexiones e interacciones que tienen lugar entre los elementos fundamentales y cuanto mayor sea el número y la diversidad de éstos. Argumenta que la causa del surgimiento y desaparición de todas las formas de complejidad es la energía que fluye a través de la materia en ciertas condiciones de contorno, a las que denomina: condiciones "goldilocks".
Cómo le denomina	Enfoque cualitativo de la complejidad.
Justificación	Servir de plataforma interdisciplinaria y sembrar una toma de conciencia con respecto al futuro de la humanidad.

hace ninguna referencia al aspecto, y es probable que su interés por negar el Big Bang (posición que adoptó Ortiz hacia el 2010) sea acorde con un desinterés por el futuro cosmológico.

En cuanto a los Hitos de la Gran Historia que son la base de un relato narrativo, por ejemplo, se muestra la Tabla 3 y 4 para Fred Spier y Pedro Ortiz Cabanillas respectivamente. Llama la atención que, en ambos casos, se trata esencialmente de la misma extensión del universo. Es como si la diferencia entre aceptar o no aceptar el Big Bang, por parte de Ortiz, no marcara ninguna distancia con un enfoque de Gran Historia que sí es consistente con la explicación de un origen del universo. Por otro lado, es evidente el contraste del desarrollo expuesto por Spier en cuanto a una dimensión cosmológica y cultural, y lo planteado por Ortiz en una dimensión biológica. Resulta evidente el aporte de Ortiz en cuanto a una explicación articulada en procesos. Procesos de la complejidad interna de los seres vivos, incluyendo personas.

DISCUSIÓN

El caso es anecdótico: dos autores rondando las mismas ideas, desarrollando su trabajo teórico de manera paralela, en la misma época, y sin conocerse, trascurriendo su vida en contextos diferentes, pero atendiendo a la necesidad histórica de explicar el universo. Fred Spier representa al investigador conectado con su tiempo (el mundo). Visita en la década de 1990 los centros más importantes donde se

Tabla 2. Caracterización de la teoría de Pedro Ortiz Cabanillas

El todo de la Gran historia	No tiene explícitamente, sino implícitamente, una Gran Historia. El universo se entiende como una totalidad de fenómenos más que como una entidad cosmológica. Dentro de esta totalidad (el universo), explica Ortiz el surgimiento y desarrollo de la complejidad (de los niveles de organización) de todos los seres vivos. Sobre el origen del universo, en la versión más madurada de su teoría, no se encuentra la asunción del Big Bang, y asume la premisa de que la materia es infinita, no tiene principio ni fin, es eterna.
Estrategias metodológicas	Usa el método científico deductivo. Se le puede ubicar en el paradigma sistémico. Más que una teoría en sí misma lo que ofrece Ortiz es un método dialéctico (no metafísico) de reinterpretación de la totalidad de los fenómenos del universo. Resumidamente, más que una explicación, la teoría de Ortiz es un instrumento que permite *reinterpretar* los fenómenos del universo (en su totalidad).
Explicación de la complejidad	Emplea el término "sistema" como toda región del universo que es objeto de observación científica. El universo está compuesto por sistemas ordenados y organizados. La complejidad es propia de los sistemas organizados. Solo hay complejidad en los sistemas vivos (es decir: organizados por información). Lo que se complejiza es la información. Los sistemas ordenados son el nivel 0 del universo. Los sistemas organizados pueden ser de 5 niveles de complejidad: 1. Unicelulares (organizados por información celular). 2. Tisulares (organizados por información metabólica). 3. Organismos (organizados por información neural). 4. Psiquismos (organizados por información psíquica). 5. Sociedad (organizados por información social). La información organiza a un sistema vivo; además, propone Ortiz una segunda definición de información: la información está reflejando el mundo interno del sistema vivo con el mundo externo al sistema vivo.
Cómo le denomina	Teoría general de la información. Psicobiología social dialéctica. Teoría Sociobiológica informacional.
Justificación	Servir de base para realizar un examen clínico integral y formación ética de personas. Formula una teoría social del hombre. Sostiene que la historia de la sociedad determina la historia de los hombres concretos, y las relaciones de los hombres igualmente concretas determinan la historia de la sociedad.

Tabla 3. Hitos de la Gran Historia por Fred Spier

- 13,7 miles de millones de años Antes del Presente (AP): La Gran Explosión
- 4 primero minutos Después de la Gran Explosión (DGE): Surgimiento de las partículas elementales.
- 4-15 minutos DGE: Nucleosíntesis del deuterio, el helio, el litio y el berilio.
- 50.000 años DGE: Transición de la era de la radiación a la era de la materia.
- 400.000 DGE: Neutralización del universo y aparición de la radiación de fondo cósmica.
- 700-2.000 millones de años DGE: Surgimiento de las galaxias y las estrellas.
- 4,6 miles de millones de años AP: Formación de nuestro sistema solar.
- 4,6-4,5 miles de millones de años AP: Aparición de los planetas telúricos.
- 4,5-3,9 miles de millones de años AP: Era hadeica, incluyendo el bombardeo cósmico.
- 3,8-3,5 miles de millones de años AP: Surgimiento de la vida.
- 3,4 miles de millones de años AP: Aparición de los más antiguos estromatolitos conocidos y surgimiento de la fotosíntesis.
- 2 mil millones de años AP: Aparición del oxígeno libre en la atmósfera y surgimiento de las células eucariotas.
- 540 millones de años AP: Explosión cámbrica de metazoos.
- 400 millones de años AP: La vida conquista la tierra.
- 200 millones de años AP: Surgimiento de los animales de sangre caliente.
- 63 millones de años AP: El impacto de un asteroide acaba supuestamente con el reinado de los dinosaurios y abre puerta a la futura dominación de los mamíferos.
- 4 millones de años AP: Surgimiento de los australopitecinos bípedos.
- 2 millones de años AP: Aparición del *Homo erectus.*
- 200 millones de años AP: Aparición del *Homo sapiens.*
- 10.000 años AP: Surgimiento de la agricultura.
- 6.000 años AP: Creación de los primeros estados.
- Hace 500 años: Primera oleada de la globalización.
- Hace 250 años: Segunda oleada de la globalización (industrialización).
- Hace 60 años: Tercera oleada de la globalización (informatización).

discute la complejidad, expone su teoría ante las lumbreras académicas de su época, plenamente documentado; como se diría: metido en la vanguardia del conocimiento científico. Por otra parte, en el Perú, Ortiz representa al investigador igualmente conectado con su tiempo (su país): demasiado original en el ejercicio científico de teorización al punto de reinterpretar totalmente la estructura de la actividad psíquica de las personas; sin embargo, a pesar de sus propios méritos, Ortiz se encontraba fuera del mundo científico de su tiempo. No es que Ortiz evada o rechace a la vanguardia científica de su tiempo; es que simplemente, esta no lo conoce. No es que no le interese, sino que Ortiz vivía en un país (el Perú) que para la década del 90 estaba asaltado por la violencia, azotado por el terrorismo, las crisis sociales, el desborde popular, las epidemias de cólera y dengue, cada vez más habituado a los cortes de luz eléctrica en las viviendas debido a que los centros de suministro eléctrico eran el primer blanco de destrucción de los ataques subversivos; y el internet, por supuesto, no existía. La distancia aparente que hay entre Spier y Ortiz sería, finalmente, la distancia entre los llamados "primer mundo" y "tercer mundo". Quien estaba aislado del mundo no era Ortiz, era el Perú; es más: Ortiz es el que estuvo más cerca de llegar a establecer el contacto (cosa que, evidentemente, no sucedió mientras vivía). Lo más interesante de todo, sin duda, es que, empezando por Ortiz, y siguiendo por todos, nadie sospechaba la existencia de estos paralelos en la vanguardia de la ciencia. Por otra parte, llama la atención lo desconectado que puede estar un país entero del orden global de las ideas; y cómo justamente en esta desconexión (que no es un retraso) parecen habitar las respuestas a las preguntas que el orden global de las ideas no puede o no se atreve a contestar.

Ahora bien, en la primera década del presente siglo, Ortiz creó un programa de postgrado (maestría y doctorado) en la universidad decana de América (Universidad Nacional Mayor de San Marcos). Evidentemente, este espacio académico le sirvió para el desarrollo y formalización de su propia teoría, ya que los libros que se usaban en los cursos eran los que Ortiz escribía; es decir, Ortiz escribía

Tabla 4. Hitos de la Gran Historia por Pedro Ortiz Cabanillas

- El universo siempre ha existido.
- Hace 4.500 millones de años: Proceso culminante de la evolución del sistema solar, con la conformación de la Tierra. Inicio de la transformación de la materia inerte en materia viva.
- Hace 4.500-1.500 millones de años: Evolución química, **procesos de biogénesis** (emergencia de los sistemas celulares).
- Últimos 1.000-700 millones de años: Aparición de sistemas vivos multicelulares con un eje corporal, **proceso de histogénesis** (emergencia de los sistemas tisulares): Espongiarios y plantas.
- Últimos 600 millones de años: Integración de los tejidos hasta la formación de redes nerviosas especializadas en la transmisión de señales eléctricas, **proceso de organogénesis** (emergencia de los sistemas orgánicos).
- Últimos 200 millones de años: Diferenciación del cerebro hasta la formación de la corteza cerebral, **proceso de psicogénesis** (emergencia de los sistemas psíquicos o psiquismos): vertebrados superiores.
- Últimos 7-6 millones de años: **Procesos de hominización,** diversificación de los homínidos en varias especies del género Homo hasta culminar con la emergencia del Homo sapiens.
- Últimos 700.000 años: **Proceso de humanización,** desarrollo de la especie Homo sapiens hasta transformarse en Humanidad (estructuración del neocórtex cerebral como una memoria capaz de codificar los procedimientos de transformación manual de los objetos naturales y del lenguaje).
- Últimos 70.000 años: **Procesos de socialización,** reestructuración social de la humanidad, sociedad tal como hoy la conocemos. Esta transformación denominamos como **proceso de sociogénesis.**

sus libros para que se estudien tanto por alumnos de la maestría como del doctorado, a fin de que estos puedan continuar en sus programas de tesis el desarrollo de la investigación teórica. En este aspecto también se asemeja a Fred Spier, quien establece una cátedra de Big History (en la Universidad de Manchester) que sirve de intercambio e investigación. Ahora, si bien la acción de Spier y Ortiz es similar, no son similares los alcances concretos que, como se ha planteado en el párrafo anterior, dependerán ya de lo que rodea a Spier tanto como de lo que rodea a Ortiz.

Ortiz recibió grandes reconocimientos en vida (fue *fellow* de *The Royal Society of Medicine*, en 1996; recibió el grado de Amauta del Perú, en 2008; la Universidad Nacional Mayor de San Marcos le entregó el Grado de Gran Cruz, en 2009, entre otros innumerables reconocimientos), y sin embargo, nada de su alcance tocó a ese otro mundo que en paralelo vibraba. Nadie se percató, por ejemplo, que cuando Ortiz publicaba su primer libro, en 1994, estaba explorando los mismos temas que las lumbreras académicas de su época. Al igual que ellos, Ortiz tenía la intención de replantear todo. Lo que para la vanguardia académica eran preguntas no resueltas, para Ortiz devinieron en necesarias reinterpretaciones. Formalmente podemos decir que el encuentro de estos dos mundos (Spier-Ortiz) está aconteciendo en estas líneas, a más de una década de fallecido Ortiz, y cuatro décadas de existencia de su teoría. Sin duda, esta ocasión debe obligar a reconocer lo que la Gran Historia está propiciando, ya que el encuentro entre Fred Spier y Pedro Ortiz Cabanillas se debe a la condición de vocación de plataforma de encuentro interdisciplinario.

La danza que se establece entre las concepciones teóricas de Fred Spier y Pedro Ortiz Cabanillas se superponen y se tocan. En resumen: el nivel cosmológico de Spier es el "Nivel 0" de Ortiz, el nivel biológico de Spier es en Ortiz el "Nivel 1" (celular), y el "Nivel 2" (tisular), y el "Nivel 3" (neural), y el "Nivel 4" (psíquico); finalmente, el nivel cultural de Spier es el "Nivel 5" (las personas y la sociedad) en Ortiz. Si procedemos a integrar los saberes (como quien suma horizontes) entre Spier y Ortiz tendríamos una Gran Historia: robusta en cosmología y sólida como filosofía de la naturaleza; florecida en la explicación de la vida: todos los seres vivos quedan reinterpretados a la luz de una visión radicalmente distinta de la interioridad compleja de los regímenes vivos; y, finalmente, cuando se integran las justificaciones de los autores: una Gran Historia ampliada en su horizonte ético.

Ahora bien, esta publicación evidencia que existe una Gran Historia en la teoría de Pedro Ortiz Cabanillas. Explícitamente, se afirma que dicha Gran Historia está implícita en la teoría de Ortiz. Sin embargo, Ortiz hizo su teoría esencialmente como soporte de un método clínico que permite reinterpretar a una persona con el objetivo de atenderlo como paciente o formarlo educativamente. Ortiz hizo su teoría, en el fondo, porque estaba buscando un método de examen clínico al paciente neurológico y psicológico (Ortiz, 1996, 1999, 2006).

Esta dimensión de la teoría de Ortiz como instrumento técnico para evaluar clínica/educacionalmente a una persona resulta difícil de integrar al marco actual de la Gran Historia. Y es que una Gran Historia con estas dimensiones y magnitudes (la Gran historia resultante de Spier-Ortiz) contaría, sin más, con la herramienta técnica para comprender el pasado y explicarnos cómo y por qué estamos donde estamos: y con esto, comprender los valores más altos anhelados; pero además tendría el método para la transformación moral de la sociedad por parte de las personas (es decir, las formas encarnadas de los valores más altos anhelados). Esta Gran Historia resultante funda, además, una explicación nueva de la interioridad; quizá la primera descripción de la complejidad interna de los seres vivos. Es, entonces, la Gran Historia el lugar donde los estudios de la Complejidad encuentran insólitamente una propuesta de solución a sus más rebuscadas preguntas. ¿Qué hubiera pasado si Spier-Ortiz (la resultante, es decir: algo que es más que la suma de las partes) hubiera estado en la década de los 90s visitando los centros de mayor vanguardia científica? ¿Cómo responderían, por ejemplo, los teóricos de la Complejidad del Instituto Santa Fe? Y más importante, ¿qué podrían decir actualmente, luego de los resultados aquí develados?

Adicionalmente, esta Gran Historia resultante suma la posibilidad de articularse con la obra de otros autores como Niklas Luhmann (1927-1998) y Fritjof Capra (1939-); ambos (desde la perspectiva de "sistemas", un concepto equivalente al de "regímenes") proponen una comprensión adicional del nivel social de complejidad (Luhmann, 2007) y la encarnación misma del cambio de paradigma científico (Capra, 1997; Capra & Luisi, 2014).

Puesta de este modo la capacidad autopoyética de las conexiones conceptuales, la Gran Historia entonces estaría encarnando en sí misma al nuevo paradigma científico (en términos de Kuhn), aspecto, a saber de los autores, inédito en la historia de los estudios de Gran Historia.

En su libro, predice Spier (2011) que quien tenga una forma de explicar la complejidad de la vida tiene asegurado un programa entero de investigación, y además, afirma que muy probablemente no va a requerir gran cosa en materia de tecnología. Ahora bien, al tiempo que Spier sostiene esta certeza, de modo paralelo Ortiz realiza todo ello de manera cabal. Entre 1984 y 2011, Ortiz desarrolla la teoría sociobiológica informacional sin más auxilio que un lapicero, unas hojas, su curiosidad empedernida y una muy sólida formación clínica como neurólogo. El aporte de Ortiz no está asociado a una gran tecnología sino a una capacidad reinterpretativa muy potente. En este sentido, el caso de Ortiz demuestra que lo que afirma Spier es cierto, Ortiz mismo es la prueba.

Epistemológicamente, aquí se ha preferido buscar el diálogo entre dos autores (propiciando la resultante integración de ambos) más que la comparación para identificar semejanzas o diferencias entre dos perspectivas que evidentemente se complementan. El desarrollo de la concepción del Estado en Spier va mucho más allá de lo que llega a tocar Ortiz incluso en su libro más político: Ética Social (Ortiz, 2007).

Spier revisa los aspectos medulares del Estados a través de los dos monopolios que ostenta, el uso de la fuerza y el cobro de impuestos, luego plantea el surgimiento de las religiones agrícolas, las religiones morales y las tres oleadas de globalización. También, explica las religiones con las nuevas actividades que realiza las primeras sociedades y las modificaciones e imposiciones de nuevos patrones de conducta que ella obliga. Por otro lado, Ortiz enfoca la historia de la humanidad en etapas más o menos definidas, primitiva, antigua y moderna en las que van surgiendo un tipo de información social predominante: tradicional, cultural y económica.

Un aspecto para próximas investigaciones sería entrar a tallar en la síntesis más profunda de la última complejidad tanto para Ortiz como para Spier. La explicación de Ortiz conduce necesariamente a la consideración de la educación, la salud y la ética como tres tecnologías sociales. Es decir, herramientas que cuentan las personas para construir su moralidad superior. En el cierre de su libro, dice Spier que la cuestión está en decidir si se va a seguir como hasta ahora o se va a cambiar. Ortiz coincidiría en resaltar la necesidad de dar una respuesta a esta pregunta. Lamentablemente, Ortiz no está ya para conversar con Spier, pero siguiendo a Spier-Ortiz habremos de reconocer que solo a las personas les ocurre aquello de vivir en sus ideas, en sus escritos, es decir: la posibilidad de trascender a la muerte. Esta publicación es testimonio evidente de dicha condición.

DECLARACIÓN DE CONFLICTO DE INTERÉS

Los autores declaran no tener ningún conflicto de interés.

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Two Theoretical Perspectives to Explain Big History: Fred Spier & Pedro Ortiz Cabanillas

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ABSTRACT

The central hypothesis of this research is that there are currently two theoretical proposals within the Big Story: the better known proposal of Fred Spier (1952 -) and the lesser known proposal of Pedro Ortiz Cabanillas (1933 – 2011) implicitly contained in his Sociobiological Informational Theory.

METHODS

We will proceed to present and synthesize the two theories of Big History made by Spier and Ortiz, comparing them and identifying points of contact and differences.

RESULTS

Spier's theoretical proposal presents the becoming of the universe in three moments: cosmological, biological and social. The epistemological basis being a qualitative theory of complexity. Ortiz's proposal (based on a qualitative theory of information) presents the evolution of the universe in six levels of complexity. In parallel, we would have: level 0 (Spier's cosmological moment); level one, two, three and four (Spier's biological level); and level 5 (Spier's social moment). There are occasional differences between the two approaches, but more are the articulations and points of contact.

CONCLUSIONS

The hypothesis of this research is correct: Spier (explicitly) and Ortiz (implicitly) have explanatory theories of Big History. Even if Spier and Ortiz never had contact (neither personally nor academically), their theories are articulated in the same explanatory scheme and are epistemologically nourished simultaneously. The Big History is strengthened by what is presented here.

KEY WORDS:

Information, Complexity, Macrohistory, Regime, System.

INTRODUCTION

The authors of Big History (also called Macrohistory) approach human history in the broad context of cosmic history: from the beginning of the universe to the present time (Hesketh, 2014). Thus, the claim of Big History is the explanation or understanding of the totality of the universe (Spier, 2005). To this end, Big History integrates and synthesizes studies related to the past but from a novel and coherent perspective that comes from, among other sciences, astronomy, geology, biology, anthropology (Christian, 2008). Big History is a relatively new field of knowledge and publications that brings together a myriad of authors (Vélez, 1994; Gamero-Valdivia, 1999; Christian, 2004; Noah-Harari, 2018, 2016, 2011) who show a global historical coincidence in the quest for explanation from a totalising vision (Conrad, 2017; McNeill & McNeill, 2004). It is crucial to note the creation of the Big History projects by Bill Gates and David Christian, the International Big History Association in August 2010, and the creation of the European Big History Network in September 2017.

In a general but synthetic way, the explanations (and the positions of the authors) within Big History can be grouped into two. On the one hand, we have the authors who use storytelling to present their Big History approach on the basis of specifically selected milestones. On the other hand, we have authors who do theory when explaining the Big Story. If we assume that water molecules move randomly in the oceans, then the job of a Big Historian (with a theoretical perspective) is to identify ocean currents, waves, tsunamis, etc. Specifically, Big History was born from the hand of the first approach (storytelling), and it is in the first approach that this discipline has reverberated and reverberates the most today (Villmoare, 2023).

From the second approach (theory) while explaining the Big Story, we have, to the best of the authors' knowledge, only one case: Fred Spier (Spier, 2023, 2011, 1996).

When theory is done in Big History, it is the theory that guides the explanation. A theory is evidenced from behind (inside or underneath) the historical landmarks. A theory explains, articulates, presents, organizes. In other words, it theories (redundancy aside) the historical landmarks. Since Big History is the history of the universe, a theory of Big History will always be a theory of the universe (i.e. a theory that explains the totality). This totality is reflected in the natural transdisciplinarity that Big History engenders. In this sense, a Big History theory is a kind of macro-theory that would include within itself a cosmological theory, a biological theory, and a sociological theory at the very least. Such an explanation necessarily has or must have a complex systems approach and allows (or must allow) complex phenomena to be resolved. Because of all these ramifications, developing a theory in Big History is particularly difficult, which highlights how significant and innovative Fred Spier's work is.

Fred Spier studied biochemistry, cultural anthropology and social history in the Netherlands during the 1980s and early 1990s. This gave him the opportunity to research politics and religion in Peru, concentrating on a small rural community in the Zurite region of Cuzco called the parish of San Nicolás de Bari.

Fred Spier studies Big History from a theoretical perspective. He makes a theory, or he uses his theory. As the author himself points out. In 1996, he published the book The Structure of Big History, in which he outlines his theory of Big History in terms of "regimes" (an interdisciplinary equivalent that is more appropriate than the traditional concept of "system") (Spier, 2023, 1996). Sources for Spier's vision include, among others, the reflections of astrophysicist Eric Chaisson (Chaison, 2001) and Erich Jantsch (Jantsch, 1980). Spier published Big History and the Future of Humanity (Spier, 2010, 2011), a book that synthesizes and formally states his theory of Big History, unveiling Big History as an interdisciplinary field (Spier, 2008).

On the other hand, a true example of theoretical creativity has been emerging in Peru since the 1980s. Pedro Ortiz Cabanillas, a Peruvian, carried out this action (1933–2011).

Ortiz developed a sociobiological explanation of the universe between 1984 and 1994. He then applied a general theory of information between 1994 and 2011, which essentially explains how the nervous system, the body as a whole, society, the individual, and the universe are related (or rather, how they are integrated and organized) (Ortiz, 2010, 2004, 1997, 1994). Ortiz is known as one of the most prominent neurologists, perhaps the greatest of all, within the Peruvian medical tradition (Contreras Pulache et al., 2019; Contreras Pulache et al., 2018).

On the other hand, there is no document citation or reference to consider that Ortiz was aware of the concept/discipline/word "Gran Historia". However, Ortiz's theory has an implicit Big History. A second theoretical approach to Big History will be exposed if this implicit Big History is discovered and made public.

Two theoretical perspectives on Big History will be discussed in this paper. One, that of Fred Spier, expressly stated and institutionally recognised in Big History studies. And two, the approach to Big History implicitly found in the theory of Pedro Ortiz Cabanillas (which, for the first time, this publication will make explicit).

METHODOLOGY

A qualitative, bibliographical study was made with a theoretical approach oriented towards the delimitation and analysis of the approaches of Fred Spier (1952-) and Pedro Ortiz Cabanillas (1933-2011). In the case of Fred Spier, his book "Big History and the Future of Humanity" (Spier, 2010) was used; while in the case of Pedro Ortiz, his book "Introducción a una Psicobiología del Hombre" (Ortiz, 2010) was taken into account.

The book "Big History and the Future of Humanity" compiles Fred Spier's theoretical proposal in relation to Big History. In 1996, the author presented a preliminary version of his approach in the book "The Structure of Big History" (Spier, 1996). During the period between 1996 and 2005, Spier presented his theory in important research centres (such as the Santa Fe Institute, among others), and these experiences allowed him to give final shape to his proposal. In addition, at the University of Amsterdam, Spier created the Big History course, which today is a global teaching model for Big History, as evidenced by its adaptation to digital mass media, including the Big History digital course on the digital education platform Coursera. According to Fred Spier, his work "Big History and the Future of Humanity" summarizes all the experience accumulated between 1996 and 2005, presenting his final theoretical proposal on Big History. The author of this text attempts to explain the modern world in eight chapters, beginning with the Big Bang as the universe's beginning. Thus, he takes into account the definition of key terms such as complexity, matter, energy, regimes, goldilocks conditions, among others. At the same time, he explains central aspects, such as the evolution of the cosmos, the emergence of life, the appearance of the brain and consciousness, primitive history and human history, states, globalization, industrialisation, including a vision of the future of humanity in terms of the state of the earth's resources.

The book, in its second edition, "Introduction to a Psychobiology of Man", by Pedro Ortiz Cabanillas, consists of seven chapters in which the author sets out his Sociobiological Informational Theory that seeks to explain the universe, relating it to society in general and the nervous system in particular. In his book, Ortiz explains and develops themes such as the levels of organization of life and the related types of information, the epigenetic and kinetic determination of living systems, offering a genuine definition of information (a general theory of information) and of the individual as a personality. When Ortiz publicly announced his research project in 1980, it is evident that his aim from 1980 to 2011 was devoted to developing a clinical examination of a patient. However, by 1984, Ortiz realized that a theory of the universe would need to serve as the general framework for developing his clinical method. In this sense, Ortiz is not explicitly elaborating a theory (at least this was not his original intention) but it becomes a theory as a necessary condition for his own end: to have an explanatory mode of what people are like inside, and thus to explain their health and illness processes through an original and unique clinical examination. Rethinking conventional patient care methods, Ortiz's clinical approach is one of those (as of yet unfinished) attempts to create a new human medicine (already at the explanatory, procedural, and diagnostic levels).

A thorough study of both volumes was conducted witA thorough study of these two books was conducted with the objectives of first determining the theoretical suggestions made by Spier and Ortiz, either openly or implicitly, and secondly outlining the key historical turning points that each theory suggested. Bibliographic sheets and comparison diagrams were made as a result. Furthermore, a 30 hour synchronous academic programme of 10 sessions was implemented, based on the general framework of a Reading Club entitled "Pedro Ortiz Cabanillas' Informational Sociobiology as a Big History" that was conducted in Lima, Peru in the summer of 2023 under the direction of one of the authors (HCP).

In these academic sessions, selected excerpts from both books were critically read, commented on, compared and critiqued. A total of 10 professionals from different backgrounds (medicine, psychology, education, philosophy, history and other social sciences) participated in these sessions; all the authors of this publication were part of this group.

The following factors were taken into consideration in order to operationalize the theoretical concepts' presentation and analysis:

- The Whole of the Big Story: which refers to how the “whole” is conceived in each of the authors’ theoretical proposals.

- Methodological strategies: related to the tools and methods followed by the authors in the process of exposition and elaboration of their theories.

- Explanation of complexity: which refers to the explanation of complexity presented within the theoretical explanation. Both Ortiz and Spier elaborate theories that explain complexity (Spier explicitly states this; Ortiz employs a novel understanding of the term “information” to correlate it with the complexity of living systems as informational systems. This implies the following: when Spier discusses complexity, it aligns with Ortiz’s discourse on informational systems). In both cases, the Big Story becomes more apparent as this intricacy plays out. The point of contact that enables Spier and Ortiz to communicate is complexity.

- Denomination: referring to the name assigned to it by each author in his exposition.

- Justification: which refers to the reasons given by each author for the goal or justification of their theory.

Finally, following the exposition of both authors, we have proceeded to specify the milestones of the Big History, which are explicitly or implicitly presented by both Fred Spier and Pedro Ortiz Cabanillas. Informative tables have been drawn up to present the results.

RESULTS

Table 1 shows the features of Fred Spier’s theory of the Big Story. This Big History takes place in 3 moments of complexity: before life (1), with life (2), and with the presence of men (3). Spier’s totality is the cosmological totality. Then, the totality of life, and finally, the totality of people and society. It begins with a Big Bang and runs through the entire history of the universe.

Table 2 shows the features of Pedro Ortiz Cabanillas’s theory of the Big History, implicitly stated in the development of his ideas. According to Ortiz’s Big History hypothesis, the cosmos is divided into six levels, Level 0 representing the age of the universe prior to the emergence of life. This concept is known as the Ortiz totality. The complexity that Ortiz explains would be (and in great detail) the internal complexity of all living things. In this sense, he deploys 5 informational levels of complexity. Society is the fifth level and includes people.

Both authors agree on the method. Beginning with the universe entails beginning with something higher above. To begin with the universe, according to Ortiz, is to begin with that which is further back. Both aspire to cover the totality of phenomena, showing the same approach that goes from the whole to the parts (and not the other way around). What Spier calls complexity level 1 (history before the presence of living beings) constitutes Ortiz’s Level 0. Spier’s cosmological unfolding has no equivalent (?) to Ortiz. Ortiz’s theory is not interested in the cosmological but in the natural philosophical. On the other hand, what Spier considers as the third level of complexity is for Ortiz the fifth level of informational complexity. Here, we can state that both theories move under the same symphony. In this sense, Spier’s second level of complexity is explained by Ortiz in four waves of detail that expand and deepen Spier’s horizon. And finally, Spier’s third complexity is exposed by Ortiz as part of the emergence of the fifth informational complexity: the explanation of the five levels of internal organization of a person, on the one hand; and, on the other hand, the explanation of “social information”. As for the future of Big History, the only one who has studied this is Spier; Ortiz does not refer to the aspect, and, likely, his interest in denying the Big Bang (a position Ortiz adopted around 2010) is in line with a disinterest in the cosmological future.

As for the Big Story milestones that are the basis of a narrative account, for example, Tables 3 and 4 are shown for Fred Spier and Pedro Ortiz Cabanillas respectively. It is striking that, in both cases, it is essentially the same extent of the universe. It is as if the difference between accepting or not accepting the Big Bang, on the part of Ortiz, does not mark any distance from a Big History approach that is consistent with the explanation of the origin of the universe. On the other hand, the contrast between Spier’s development of a cosmological and cultural dimension and Ortiz’s development of a biological dimension is evident. Ortiz’s contribution is evident in terms of an explanation articulated in processes. Processes of the internal complexity of living beings, including humans.

DISCUSSION

This is anecdotal: two authors working on the same ideas, developing their theoretical work in parallel, coincidentally, and without knowing each other, living in different social contexts but attending to the historical need to explain the universe. Fred Spier represents the researcher connected with his time (the world). He presented his completely documented theory to the leading academics of his day in the 1990s, travelling to the most significant venues for complexity discussions. It could be argued that he was at the forefront of scientific knowledge, not only in Big History studies but also in complexity studies and various other fields.On the other hand, in Peru, Ortiz represents the researcher equally connected with his time (his country). During the 1990s and the first decade of the 21st century, Ortiz remained outside the scientific community. However, his scientific theorizing was exceptionally inventive, to the extent that it led to a complete reinterpretation of the structure of human psychic activity. It's not that Ortiz intentionally evaded or rejected the scientific avant-garde of his time; rather, he lived in a country (Perou, before the arise of internet era) disconnected from the more advanced scientific knowledge produced by developed countries. It is not that he was not interested, but rather that Ortiz lived in a country (Peru) that by the 1990s was beset by violence, plagued by terrorism, social crises, popular upheaval, cholera and dengue epidemics, and increasingly accustomed to power cuts in homes because electricity supply centres were the first target for destruction by subversive attacks; and the internet, of course, did not exist. The apparent distance between Spier and Ortiz would ultimately be the distance between the then so-called "first world" and "third world". It was not Ortiz who was cut off from the world, it was Peru; moreover, Ortiz is the one who came closest to establishing contact (which, evidently, did not happen while he was alive). The most interesting thing of all, no doubt, is that, starting with Ortiz and continuing with everyone else, no one suspected the existence of these parallels at the forefront of science (and, obviously, Big History science). The most fascinating fact of all, without a question, is that nobody at the forefront of science, beginning with Ortiz and continuing with everyone else, had any inkling that these analogies existed. On the other hand, it is remarkable how cut off a nation may be from the world order of ideas and how the solutions to the issues that the global order of ideas either cannot or dare not answer seem to dwell exactly in this cutoff.

Nowadays, in the first ten years of the current century, Ortiz established a master's and doctoral postgraduate curriculum at Universidad Nacional Mayor de San Marcos, the oldest institution in America. Evidently, this academic space served him for the development and formalization of his own theory since the books used in the courses were those that Ortiz wrote; in other words, Ortiz wrote his books so that they could be studied by both master's and doctoral students, so that they could continue the development of theoretical research in their thesis programmes. In this respect he also resembles Fred Spier, who establishes a chair in Big History (at the University of Amsterdam) for exchange and research. As mentioned in the preceding paragraph, Spier and Ortiz have identical actions, but their concrete scopes differ. This is because Spier's action will depend just as much on his surroundings as Ortiz's will.

Ortiz was highly honoured during his lifetime (among many other honours, he was named a Fellow of the Royal Society of Medicine in 1996, elevated to the rank of Amauta of Peru in 2008, and given the Degree of Grand Cross by the Universidad Nacional Mayor de San Marcos in 2009) but despite all these merits, none of his work was internationally recognized. For example, nobody understood that in 1994, when Ortiz released his first book, he was delving into the same issues as the leading academics of the day. Ortiz planned to reconsider everything, just like them. There were unanswered problems for the academic avant-garde; for Ortiz, a reinterpretation was required. We may state that after more than ten years after Ortiz's passing and four decades of the existence of his theory, the merging of these two worlds (Spier-Ortiz) is occurring along these lines. This event should undoubtedly compel us to acknowledge the significance of what the Big History is propitiating, since the contact between Pedro Ortiz Cabanillas and Fred Spier is a result of vocation serving as a forum for interdisciplinary interactions.

The theoretical conceptions between Fred Spier and Pedro Ortiz Cabanillas overlap and touch. In short, Spier's cosmological level is Ortiz's "Level 0," Spier's biological level is Ortiz's "Level 1" (cellular), "Level 2" (tissue), "Level 3" (neural), and "Level 4" (psychic) and finally, Spier's cultural level is Ortiz's "Level 5" (people and society). A Big History that is strong in cosmology and firm as a philosophy of nature, flourishing in its explanation of life—all living things are reinterpreted in the context of a radically different understanding of the intricate interiority of living regimes—would result from continuing to integrate the knowledge (as one adds horizons) between Spier and Ortiz. Finally, when the authors' arguments are combined, we obtain a Big History that is expanded in its ethical horizon.

This publication shows a lot of history in Pedro Ortiz Cabanillas' theory. Explicitly, it is stated that such a big history is implicit in Ortiz's theory. However, Ortiz made his theory essentially a support of a clinical method that allows to reinterpret a person to attend to him as a patient or to train him educationally. Ortiz made his theory, in essence, because he was looking for a method of clinical examination of the neurological and psychological patient (Ortiz, 2006, 1999, 1996).

This dimension of Ortiz's theory as a technical instrument to clinically or educationally evaluate a person is difficult to integrate into the current framework of the Big Story. A Big History with these dimensions and magnitudes (the resulting Big History of Spier-Ortiz) would have the technical tools to understand the past and explain how and why we are where we actually are in order to understand the highest desired values. However it would also have the method for the moral transformation of society by people (i.e., the embodied forms of the highest desired values). This resulting Big History also found a new explanation of interiority—perhaps the first description of the inner complexity of living beings. It is, then, the Big Story where complexity studies unusually find a proposed solution to their most far-fetched questions. What would have happened if Spier-Ortiz (something that is more than the sum of its parts) had been in the 1990s visiting the most cutting-edge scientific centres? How would, for example, the complexity theorists of the Santa Fe Institute respond? And more importantly, what might they say today, after the results are unveiled here?

Additionally, this resulting Big History adds the possibility of articulating with the work of other authors such as Niklas Luhmann (1927–1998) and Fritjof Capra (1939–); both (from the perspective of "systems," a concept equivalent to "regimes") propose an additional understanding of the social level of complexity (Luhmann, 2007) and the very embodiment of the scientific paradigm shift (Capra, 1997; Capra & Luisi, 2014).

Stated differently, the authors' understanding of a component yet unexplored in the Big History studies literature—the autopoietic potential of conceptual connections—would thereby incorporate in itself the new scientific paradigm (in Kuhn's terminology).

In his book, Spier (2011) predicts that whoever has a way of explaining the complexity of life is assured of an entire research programme, and he claims that it will most likely not require much in the way of technology. However, while Spier maintains this certainty, Ortiz does all this in a parallel way. Between 1984 and 2011, Ortiz developed informational sociobiological theory with nothing more than a pencil, a few sheets of paper, his inveterate curiosity, and a very solid clinical training as a neurologist. Ortiz's contribution is not associated with great technology but with a very powerful reinterpretative capacity. In this sense, Ortiz's case shows that what Spier says is true; Ortiz himself is the proof.

Epistemologically, the preference here has been to seek a dialogue between two authors (leading to the resulting integration of the two) rather than a comparison to identify similarities or differences between two perspectives that complement each other. The development of Spier's conception of the state goes far beyond what Ortiz touches on even in his most political book, "Ética Social" (Ortiz, 2007).

On the other hand, this article has asserted that there is currently only one theoretical proposal in Big History (developed by Fred Spier) and that what Pedro Ortiz Cabanillas proposes represents an alternative. This can be debated, and it undoubtedly represents a limitation of our publication. In the future, it is expected that research will be conducted to contrast the potential theoretical proposals of Eric Chaisson (in his book "Cosmic Evolution"), Tyler Volk (in his book "Quark to Culture"), and even Alexander von Humboldt (in his book "Cosmos"). Thus, this publication firmly establishes itself as the formal inception of a line of research aimed at contrasting and elucidating the existing theories within Big History.

Spier reviews the core aspects of the state through the two monopolies it holds—the use of force and the collection of taxes—and then discusses the emergence of agricultural religions, moral religions, and the three waves of globalization. He also explains the religions with the new activities carried out by the first societies and the modifications and impositions of new patterns of behaviour that they force. On the other hand, Ortiz focuses on the history of mankind in more or less defined stages, primitive, ancient, and modern, in which a type of predominant social information emerges: traditional, cultural, and economic.

An aspect for further research would be to go into an exhaustive synthesis of the latter complexity for both Ortiz and Spier. Ortiz's explanation necessarily leads to considering education, health, and ethics as three social technologies. Tools that people rely on to construct their higher morality. In the closing of his book, Spier says that the matter is whether to continue as before or to change. Ortiz would agree with highlighting the need to give an answer to this question. Sadly, Ortiz is no longer with us to discuss with Spier; yet, in the spirit of Spier-Ortiz, we have to acknowledge that only humans possess the capacity to live on in their thoughts and works, that is, the capacity to transcend death. This article clearly attests to this state of affairs.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest.

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Table 1. Characterisation of Fred Spier's theory

The whole of the Big Story	The whole is the extension from the origin of the universe (the Big Bang) to the present day. It presents a position that assumes a big bang.
Methodological strategies	Perspective: holistic. Big History attempts to map knowledge of the whole past. It uses the scientific method from the whole to the parts. Its description is top-down: from the subatomic particles of the universe to the galaxy, the solar system, the earth, life, culture.
Explanation of complexity	It interchanges the term "regime" with the term complexity. He conceives of three general levels of complexity: 1. That of physically inanimate nature. Non-living matter. Cosmic matter. Pre-biological stage. No information centres exist. 2. That of life. The information centre is in the DNA. Life is sustained by gathering matter and energy. 3. Culture. This is the information stored in the nerves and brain cells of human beings. A regime is more complex the more numerous and varied the connections and interactions that take place between the fundamental elements and the greater the number and diversity of these. He argues that the cause of the emergence and disappearance of all forms of complexity is energy flowing through matter under certain boundary conditions, which he calls "Goldilocks" conditions.
How is it named	Qualitative approach to complexity.
Support	To act as an interdisciplinary forum and to spread consciousness on humanity's future.

Table 2. Characterisation of Pedro Ortiz Cabanillas's theory

The whole of the Big Story	It has, not explicitly but implicitly, a Big History. The universe is understood as a totality of phenomena rather than as a cosmological entity. Within this totality (the universe), Ortiz explains the emergence and development of the complexity (of the levels of organisation) of all living beings. On the origin of the universe, in the most mature version of his theory, there is no assumption of the Big Bang, and he assumes the premise that matter is infinite, has no beginning and no end, and is eternal.
Methodological strategies	Uses the deductive scientific method. It can be placed inside the systems theory tradition. More than a theory in itself, what Ortiz offers is a dialectical (not metaphysical) method of reinterpreting the totality of the phenomena of the universe. In short, more than an explanation, Ortiz's theory is an instrument for reinterpreting the phenomena of the universe in their totality.
Explanation of complexity	He uses the term "system" to refer to any region of the universe that is the subject of scientific observation. The universe is composed of ordered and organised systems. Complexity is characteristic of organised systems. There is complexity only in living systems (i.e., organised by information). What becomes complex is information. Ordered systems are level 0 of the universe. Organised systems can have five levels of complexity: 1. Unicellular (organised by cellular information). 2. Tissular (organised by metabolic information). 3. Organisms (organised by neural information). 4. Psyches (organised by psychic information). 5. Society (organised by social information). Information organises a living system; furthermore, Ortiz proposes a second definition of information: information is reflecting the internal world of the living system with the world external to the living system.
How is it named	General information theory. Dialectical social psychobiology. Sociobiological information theory.
Support	To serve as a basis for a comprehensive clinical examination and ethical training of people. It formulates a social theory of man. It is argued that the history of society determines the history of individual human beings, and the relationships of individual human beings also determine the history of society.

Table 3. Milestones of the Big Story by Fred Spier

- 13.7 billion years Before Present (AP): The Big Bang
- 4 first minutes After the Big Bang (GBD): Emergence of Elementary Particles.
- 4-15 minutes DGE: Nucleosynthesis of deuterium, helium, lithium, and beryllium.
- 50,000 years DGE: Transition from the era of radiation to the era of matter.
- 400,000 GID: Neutralisation of the universe and emergence of the cosmic background radiation.
- 700-2,000 million years AGE: Emergence of galaxies and stars.
- 4.6 billion years BP: Formation of our solar system.
- 4.6-4.5 billion years BP: Emergence of telluric planets.
- 4.5-3.9 billion years BP: Hadean Era, including cosmic bombardment.
- 3.8-3.5 billion years BP: Emergence of life.
- 3.4 billion years BP: Appearance of the oldest known stromatolites and emergence of photosynthesis.
- 2 billion years BP: Appearance of free oxygen in the atmosphere and the emergence of eukaryotic cells.
- 540 million years BP: Cambrian metazoan explosion.
- 400 million years BP: Life conquers the earth.
- 200 million years BP: Rise of warm-blooded animals.
- 63 million years BP: Asteroid impact supposedly ends the reign of dinosaurs and opens the door to the future dominance of mammals.
- 4 million years BP: Emergence of bipedal australopithecines.
- 2 million years BP: Appearance of Homo erectus.
- 200 million years BP: Emergence of Homo sapiens.
- 10,000 years BP: Emergence of agriculture.
- 6,000 years BP: Creation of the first states.
- 500 years ago: First wave of globalisation.
- 250 years ago: Second wave of globalisation (industrialisation).
- - 60 years ago: Third wave of globalisation (computerisation).

Table 4. Milestones of the Big Story by Pedro Ortiz Cabanillas

- The universe has always existed.
- 4.500 million years ago: The culminating process of the evolution of the solar system began with the formation of the Earth. Beginning of the transformation of inert matter into living matter.
- 4.500-1.500 million years ago: Chemical evolution, biogenesis processes (emergence of cellular systems).
- Last 1,000–700 million years ago: Appearance of multicellular living systems with a body axis, process of histogenesis (emergence of tissue systems): Spongiaria and plants.
- Last 600 million years: Integration of tissues up to the formation of nerve networks specialised in the transmission of electrical signals, process of organogenesis (emergence of organ systems).
- Last 200 million years: differentiation of the brain until the formation of the cerebral cortex, process of psychogenesis (emergence of psychic systems or psyches): higher vertebrates.
- Last 7–6 million years: Hominisation processes, diversification of hominids into various species of the genus Homo, culminating in the emergence of Homo sapiens.
- Last 700,000 years: Process of humanisation, development of the species Homo sapiens to become Humanity (structuring of the cerebral neocortex as a memory capable of codifying the procedures of manual transformation of natural objects and language).
- Last 70,000 years: Socialisation processes, social restructuring of humanity, and society as we know it today. We call this transformation a process of sociogenesis.

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A Big History of One's Own*

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"In most books, the *I*, or first person, is omitted; in this it will be [mostly] retained."[1]

I know only what I know. What I know is limited, usually from that limited life experience that I have had, i.e., with the near at hand as anchor. I love those who gave me life and provide me with life's necessities, especially those with a natural inkling of attachment. I wish to see the due wish of each and every one of us humans be granted and satisfied. I like to see the world flourish on the order of its participants roaming freely as well as following rules and keeping promises. If I wish to know and experience further, to the point of knowing the whole, I have to rely on the effort and fruit of others, every one of them. And even so, what I finally fathom and get is something of my own. It's an exploration of my own self in a larger world after all.

Briefly here, I wish to say that big history suffers from not being criticized enough. To compensate for this, big historians are doing or to do two things: self-criticizing, and the construction of more big histories of one's own. This is an advocate, as well as an attempt to do so, from the perspective of a conscientious Chinese scholar, in the hope of inviting more potential big historians, to share their views and visions concerning how humanity has evolved and is evolving in the context of a changing universe. In other words, by doing big history, we are on our way to answering the question: How should humanity proceed in a conscientiously constructive mode of sustainability and harmony?, i.e., if ever that's possible. My own answer revolves around the playing out of science, love, law and order. This is followed by a suggestion of possible topics to be addressed by big historians in years to come.

The Emergence and Gist of Big History

Transdisciplinary effort

When David Christian (1946-) of Macquarie University, in the late 1980s, was trying to catch the totality of history in his seemingly "creation myth" account, he was truly aiming at something big:

> … I couldn't shake off the idea of a nontribal history of humanity, so I tried to figure out what such a course might look like. The prospect was daunting. To teach the history of humanity I would have to survey not just 200 years (as I did in my Russian history courses), but 200,000 years. And to do it properly, I would have to discuss the evolution of human beings, which meant introducing some biology. After all, you can't really understand humans without comparing them to other animals. So where did these questions end? Was there a point beyond which larger and larger frameworks ceased to yield new and interesting questions? If there was, I couldn't find it. To really understand human evolution, I realized I would have to study the evolution of other species, which would take me back 3.8 billion years to the origins of life on earth. That scale would help me understand the place of humans within the history of life on earth. But to understand the history of life wouldn't I also have to study geology and the history of the earth, and wouldn't that lead me to astronomy and, heaven help me, to cosmology?[2]

That was the beginning of and the reasoning behind what David Christian would later, hesitatingly, style

1 * A draft version of this paper was first presented at the online Fifth International Symposium themed "Big History and Global Evolution," Moscow, October 24–26, 2023; and shortly later at the annual conference sponsored by the Center of History and Theory Studies under the Chinese Academy of Social Sciences (CASS) themed "Western Historical Theories: Viewpoints and Schools of Thought," Beijing, November 4, 2023. Henry D. Thoreau, *Walden, or Life in the Woods*, with an Introduction by Joseph Wood Krutch (New York: Harper & Brothers, 1950), p. 2.

2 David Christian, "Big history," in *Architects of World History: Researching the Global Past*, eds. Kenneth R. Curtis and Jerry H. Bentley (Chichester, UK and Malden, MA: John Wiley & Sons, 2014), p. 195.

as "big history".[3] David says he was "moved toward big history" because he is, "by instinct, a 'framework' thinker," i.e., someone who relies on an overall theoretical framework to claim understanding.[4] To achieve such an overall framework, David turned to his colleagues for help: astronomer David Allen, biologist David Briscoe, paleontologist Mike Archer, anthropologists Annette Hamilton, Bob Norton, and Ian Bedford, et al, as he listed in his reflections decades later. [I wonder why, as a gesture of academic courtesy, he did not trouble to seek help from mythologists, philosophers or theologians, for, "[i]n the past, at least," such "big" questions "have been the preserve mainly of mythologists, theologians, metaphysicians, and philosophers of history. Is it possible that the situation is now changing?"[5]] Meanwhile, he and his historian colleagues "struggled to integrate the complex and contested narratives of human history into the larger narrative of big history."[6]

Narrative threads

The "integration" of all human knowledge in service of the above goal is never an easy job. What the pioneering big historians do is to unify their narratives by way of a number of threads or structural principles, like "transmutations", "fractal", "equilibrium systems", "regimes", "punctuated equilibria", "constructal law", "combogenesis",[7] etc. David Christian's narrative threads are "a series of threshold moments" – "moments that see sudden forms of complexity appear," like the Big Bang, the stars, the origins of the solar system, the emergence of life on Earth, etc., plus "collective learning" (the ability to share knowledge over space and time), a power that is unique to us humans.[8]

David describes big history as "the transdisciplinary study of the entire past – not just of humanity or even the earth, but of the entire universe."[9] The official website (https://bighistory.org) of the International Big History Association – established in 2010 – claims: Big history seeks to understand the integrated history of the Cosmos, Earth, Life, and Humanity, using the **best** available empirical evidence and **scholarly** methods. Gradually, big history has assumed the following structure, following the IBHA (International Big History Association, founded in 2010) official website:

> Beginning about 13.8 billion years ago, the story of the past is a **coherent** record that includes a series of great thresholds. Beginning with the Big Bang, Big history is an **evidence-based** account of emergent complexity, with simpler components combining into new units with new properties and greater energy flows.

The bold-fonted words – bold-fonted by this author – around here are highly suspicious: Are these a description of "facts" or are they simply a stance or aim chosen by the authors? Or how good or coherent is the job done? Questions like these certainly merit more serious arguments and debates. But anyway, the first ever big history textbook,[10]

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3 David Christian, "The Case for 'Big History'," *Journal of World History*, Vol. 2, No. 2 (Fall, 1991), pp. 223-238; Marnie Hughes-Warrington, "Big History," *Historically Speaking*, Vol. 4, No. 2 (Nov., 2002), p. 16.

4 Christian, "Big history," pp. 191-193, quote on p. 191.

5 Jared Diamond, *Guns, Germs, and Steel: The Fates of Human Societies* (New York: W. W. Norton, 1997); Fred Spier, *The Structure of Big History: From the Big Bang until Today* (Amsterdam: University of Amsterdam Press, 1996). Review by Bruce Mazlish, "Big Questions? Big History?," *History and Theory*, Vol. 38, No. 2 (May, 1999), pp. 232-248, quote on p. 232.

6 Christian, "Big history," pp. 196-197.

7 Sun Yue, "Big History," in *Bloomsbury History: Theory and Method*, eds. Stefan Berger, et al (London: Bloomsbury, 2021). http://dx.doi.org/10.5040/9781350970847.044.

8 Ian Hesketh, "The Story of Big History," *History of the Present*, Vol. 4, No. 2 (Fall 2014), pp. 176-181; Ian Hasketh, "What big history misses," *Aeon*, December 16, 2021, https://aeon.co/essays/we-should-be-wary-about-what-big-history-overlooks-in-its-myth, accessed January 28, 2022. For more, see David Christian, "Collective Learning," in *Berkshire Encyclopedia of Sustainability: The Future of Sustainability*, Vol. 10, ed. Ray C. Anderson (Great Barrington, MA: Berkshire Publishing, 2012), pp. 49-56; David Baker, "Collective Learning: A Potential Unifying Theme of Human History," *Journal of World History*, Vol. 26, No. 1 (Mar., 2015), pp. 77-104.

9 Christian, "Big history," p. 190.

10 David Christian, Cynthia Stokes Brown, and Craig Benjamin, *Big History: Between Nothing and Everything* (New York: Mc-

obviously more weighty and authoritative, proclaims a number of "thresholds" as a matter of historical "facts" vis-à-vis big history periodization:

The first three: The Universe, Stars, and New Chemical Elements
The fourth: The Emergence of the Sun, the Solar System, and the Earth
The fifth: The Emergence of Life
The sixth: Hominines, Humans, and the Paleolithic Era
The seventh: Origins of Agriculture and the Early Agrarian Era
The eighth: Breakthrough to Modernity
More thresholds? The History of the Future

Running throughout the current mainstream big history narratives is the idea of "increasing complexity" or "emergent complexity," a concept borrowed from Eric Chaisson, the Harvard astrophysicist, in his ground-breaking book of 2001, titled *Cosmic Evolution: The Rise of Complexity in Nature*. In this book, Chaisson defines "complexity" as "[a] state of intricacy, complication, variety, or involvement, as in the interconnected parts of a structure – a quality of having many interacting, different components; operationally, a measure of the information needed to describe a system's structure and function, or of the rate of energy flowing through a system of given mass."[11] Following this logic, some parts of the universe, including humans and human societies, become increasingly ordered and complex mediated by more and varied components and greater energy flows. This increase in complexity occurs despite the Second Law of Thermodynamics, which says the universe, as a whole, is becoming more chaotic.

"Modern creation myth"

David Christian says his wife Chardi and his paleontologist colleague Mike Archer suggested "Creation Science" and "origin story" respectively for what he was doing. And he later formally uses "creation myths" to describe his big history project.[12] By "modern creation myth" is to be understood what he calls a "coherent account of how we were created and how we fit into the scheme of things."[13] "Creation myths are powerful," argues David Christian, "because they speak to our deep spiritual, psychic, and social need for a sense of place and a sense of belonging."[14] This was echoed by Fred Spier and Cynthia Stokes Brown, who refers to their own big history narratives as "cosmic world views" or "origin myths" and "scientific creation story", respectively.[15]

So even at this foundational stage, despite the above consensus shared by big historians, big history exhibits rather personal stylistics. Fred Spier says big history should only be providing "the best possible academic narrative of the past," that big historians should never get emotional or have anything to say about "right and wrong; how to act; and how to interpret it in religious, spiritual, or metaphysical ways." He says his own "big history account" is very much like a "GPS device" – very different from "that of David Christian, or of Eric Chaisson."[16] In comparison, Eric Chaisson is more impatient of softer, weaker, wrong stuff in big history: "Will the IBHA continue to tolerate, if not pursue, baseless expressions of meaning, mysticism and personal belief, or will it embrace its own mission statement to use the 'best available empirical evidence and scholarly methods' to explore this newly emerging field that we all so treasure?," roars Eric Chaisson in his swansong thunder.[17] "Big history" as a whole, as Ian Hesheth observes, is ambitiously striving to be not only "a science, but *the* science" for all of humanity with its "grand

Graw-Hill, 2014).

11 Eric Chaisson, *Cosmic Evolution: The Rise of Complexity in Nature* (Cambridge, MA: Harvard University Press, 2001), p. 230.

12 Christian, "Big history," 197, 199. Christian, "The Case for 'Big History'," pp. 228, 235-236; and David Christian, *Maps of Time: An Introduction to Big History* (Berkeley, CA: University of California Press, 2004), pp. 1-14.

13 Christia*n, Maps of T*ime, p. 3.

14 Christia*n, Maps of T*ime, p. 2.

15 See Fred Spier, *Big History and the Future of Humanity*, 2nd ed. (Chichester, UK: John Wiley & Sons, Ltd., 2015), pp. 4-11; Cynthia Stokes Brown, *Big History: From the Big Bang to the Present* (New York: The New Press, 2007), p. xi.

16 Fred Spier, "Big History is not an all-encompassing world view," *Origins (IBHA Newsletter)*, Vol. 6, No. 2 (Feb., 2016), pp. 3-5, especially p. 4. His "GPS device," if it's ever serviceable, is probably more for interstellar AI devices than carbon-based humans.

17 See Eric Chaisson, "A Pithy Rejoinder: My Swan Song Revisited," *Origins*, Vol. IV, No. 11 (Nov., 2014), p. 21.

unifying theory."[18]

From Eulogization to Little Criticism to Self-Criticism

High praise from elites

Big history's critics are scanty and few. This is probably because of the countless difficulties involved in addressing it – very few feel well trained to comment on such open and ultimate topics, for example, but perhaps also because of the elevation of David Christian's magnum opus, *Maps of Time*, by the late world historian William H. McNeill (1917-2016) to the like of Newton and Darwin. He said:

> *Maps of Time* unites natural history and human history in a single, grand, and intelligible narrative. This is a great achievement, analogous to the way in which Isaac Newton in the seventeenth century united the heavens and the earth under uniform laws of motion; it is even more closely comparable to Darwin's nineteenth-century achievement of uniting the human species and other forms of life within a single evolutionary process.[19]

This is certainly great report, i.e., if it is true. But not everyone has agreed with this appraisal except, perhaps, the late Andre Gunder Frank (1929-2005);[20] one critic openly retorted: "Big history can cover all the time of the universe without equaling the achievements of Newton and Darwin. Combining different stories in a historical narrative and finding a scientific explanation for all possible stories are two different things."[21]

But McNeill's real interest may lie elsewhere. As he continues in his introductory remarks:

> The truly astounding dimension of Christian's accomplishment is that he finds similar patterns of transformation at every level. Here, for example, is what he says about stars and cities:
>
> In the early universe, gravity took hold of atoms and sculpted them into stars and galaxies. In the era described in this chapter, we will see how, by a sort of social gravity, cities and states were sculpted from scattered communities of farmers. As farming populations gathered in larger and denser communities, interactions between different groups increased and the social pressure rose until, in a striking parallel with star formation, new structures suddenly appeared, together with a new level of complexity. Like stars, cities and states reorganize and energize the smaller objects within their gravitational field. (p. 245)

Or weigh the words with which he closes this extraordinary book:

> Being complex creatures ourselves, we know from personal experience how hard it is to climb the down escalator, to work against the universal slide into disorder, so we are inevitably fascinated by other entities that appear to do the same thing. Thus this theme – the achievement of order despite, or perhaps with the aid of, the second law of thermodynamics – is woven through all parts of the story told here. The endless waltz of chaos and complexity provides one of this book's unifying ideas. (p. 511)

I venture to say that Christian's discovery of order amid "the endless waltz of chaos and complexity" is not just one among other unifying themes, but the supreme achievement of this work.[22]

So basically two things here: the degree of hierarchical correspondence, and life's irresistible urge to build order

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18 Hesketh, "The Story of Big History," pp. 171-172.

19 Christian, *Maps of Time: An Introduction to Big History*, p. xv.

20 See Andre Gunder Frank, "Universal History: Sizing Up Humanity in Big History," *Journal of World History*, Vol. 16, No. 1 (Mar., 2005), pp. 83-97. Andre kind of reluctantly pointed out that "[David Christian] devotes scarce attention to life and evolution … and none to their possible future"; he also said he suspected "that this earth may all too soon belong to the insects and/or single cellular microbes and viruses or others" based on the law of "evolutionary competition for survival." (pp. 83, 94)

21 Wolf Schäfer, "Big History, the Whole Story, and Nothing Less?," *Canadian Journal of History / Annales Canadienne d'Histoire*, Vol. 41, No. 2 (Autumn 2006), p. 319.

22 Christian, *Maps of Time*, pp. xvi-xvii. McNeill's quotations of David Christian are from the same book.

despite of the more chaotic spell of the second law of thermodynamics, "woven through all parts of the story". McNeill epitomizes Christian's contribution as discovering "similar patterns of transformation at every level," or as fathoming "a striking parallel" between human society and star formation, thus energizing new structures in an "endless waltz of chaos and complexity." On another occasion, McNeill refers to it as a kind of skill: "finding patterns or principles that run across different levels of reality – physics, chemistry, biology, and human behavior."[23] This comes close to the rather humane but vain attempt to give expression to a "theory of everything," or more modestly, an integration of "domains of truth."[24] Is such an attempt really obtainable by humans? This is neither the right place for an adequate argumentation nor the perfect platform to shine a brisk final answer. So, I prefer to leave it alone for the moment.

Why little criticism

Another reason why big history has been scarcely criticized is perhaps the nervous antipathy David Christian had shown toward prospective critics when big history was still very young: "Only when a modern creation myth has been teased out into a coherent story will it really be possible to take the next step: of criticizing it, deconstructing it, and perhaps improving it."[25]

So, up to now, there have been barely four or five review/critical pieces[26] that address fundamental/larger aspects of big history, but even these have remained relatively unknown so far, except, perhaps, amongst members of the relatively small organization, the IBHA. Some big historians tend to ignore differences of opinions, alternative perspectives, and genuinely fear the jarring sound of criticism. This has hindered the growth of the big history movement. It's high time for big history to be criticized, most desirably by starting with self-criticism.

Self-criticism on the rise

Initially, David Christian conceived of big history as "the exploration of the past on all these different scales, up to the scale of the universe itself,"[27] seemingly something brand new. Nineteen years later, he saw it as a "return of universal history."[28] Twenty-six years later, he reconfigured it as "the modern form of an ancient project," "debates" that "had their counterparts and echoes in many other traditions of historical scholarship," "because big history sees human history as part of a much larger past that includes the

23 Brown, *Big History*. Review by William H. McNeill, "Big History in Brief," *History and Theory*, Vol. 47, No. 2 (May, 2008), p. 302.

24 See William A. Christian, "Domains of Truth," *American Philosophical Quarterly*, Vol. 12, No. 1 (Jan., 1975), pp. 61-68; Ken Wilber, *A Theory of Everything: An Integral Vision for Business, Politics, Science, and Spirituality* (Boston: Shambala Publications, 2000); John D. Barrow, *New Theories of Everything*, 2nd ed. (Oxford and New York: Oxford University Press, 2007); Matt Crenson and Nicolle Rager Fuller, "Strung together: Is There a Theory of Everything?," *Science News*, Vol. 179, No. 9 (April 23, 2011), pp. 26-27; Lambert Zuidervaart, *Social Domains of Truth: Science, Politics, Art, and Religion* (London and New York: Routledge, 2023); etc. As an interesting aside, William H. McNeill in his autobiography once compared himself and his son to "John the Baptist, prefiguring a greater revelation coming from the hand and mind of David Christian." John McNeill later says sorry for this. See William H. McNeill, *The Pursuit of Truth: A Historian's Memoir* (Lexington, KY: The University Press of Kentucky, 2005), p. 157; John McNeill, "William H. McNeill: In Memoriam," *Origins* (IBHA Newsletter), Vol. VI, No. 8 (Sep., 2016), p. 7.

25 Christian, *Maps of Time*, p. 10.

26 Alex Moddejonge, "The Biggest Story Ever Told: A Comprehensive Analysis of the Historiographic Origins of Big History, 500 BCE to 2010 CE," California State University San Marcos, Master's Thesis, May 9, 2012; Nasser Zakariya, "Is History Still a Fraud?," *Historical Studies in the Natural Sciences*, Vol. 43, No. 5 (Nov., 2013), pp. 631-641; Hesketh, "The Story of Big History"; Mark Lupisella, "Is the Universe Enough? Can It Suffice as a Basis for Worldviews?," *The Journal of Big History*, Vol. III, No. 3 (Jul., 2019), pp. 123-140; Ken Baskin, "A Cosmological Crisis?: A Review of Nasser Zakariya, *The Final Story: Science, Myth, and Beginnings*," *Journal of Big History*, Vol. III, No. 4 (2019), pp. 171-176. Allan Megill dismisses big history as less contributive to historical knowledge than it promises and that "a better approach to meeting the desire for large scale in historical writing is through more modest endeavors, such as large-scale comparative history, network and exchange history, thematic history, and history of modernization," see his "'Big History' Old and New: Presuppositions, Limits, Alternatives," *Journal of the Philosophy of History*, Vol. 9, No. 2 (2015), pp. 306-326.

27 Christian, "The Case for 'Big History'," p. 225.

28 Christian, "The Return of Universal History," pp. 6-27.

pasts studied by biologists, paleontologists, geologists and cosmologists."[29] More recently, David Blanks, an editor of the *Journal of Big History*, actually offers a new definition of big history that seems to take account the unresolvable divide between materiality and meaning: "Big history is a self-reflective, scientific approach to the entirety of the material and human past that is interdisciplinary and open-ended, which means that we can share broad assumptions about how the world works while disagreeing about what it means."[30] These are important breakthroughs.

Occasionally, big historians disagree among themselves over fundamental issues. Fred Spier, for example, has shot at David Christian narrative pillar of "thresholds," saying it lacks academic precision and is an erroneous concept for structuring all of big history, "fatally flawed and ought to be abandoned."[31] Meanwhile, Fred prizes his own approach in his book *Big History and the Future of Humanity* (2010, 2015), treading "along the lines of transitions to greater complexity while not prioritizing any of them according to a fixed and numbered scheme that was claimed to be valid for all of big history but while also paying considerable attention to the decline and disappearance of complexity."[32] David Christian seriously argues for the value of and the constant need to return to an "unified, all-embracing knowledge,"[33] while Fred Spier diametrically retorts that "Big history is not an all-encompassing world view."[34]

Maybe as a result of this lack of methodological criticism, or despite of that, there have been open deserters, bare onlookers, and faint commentators surrounding the small big history camp. Eric Chaisson, among others, has sung his "swan song" to IBHA and perhaps the big history movement as well by publishing his final pronouncement in three journal articles related to big history – growling over its unscientific softness.[35] Yuval Noah Harari, whom Bill Gates counts as "among the most important writers" of big history,[36] and who was said to have attended the 2014 IBHA conference at San Rafael, California, in his well-known trilogy – *Sapiens*, *Homo Deus*, and *21 Lessons for the 21st Century*, barely mentioned "big history" at all.[37] The over 300-page book of 2021 *Philosophy of History: Twenty-First-Century Perspectives* has only one sentence on big history, that "it offers an interpretation of history on the largest possible scale, with human history seen within the history of the universe."[38]

In terms of institutional building, the big history program, started in 2010 as a required First-Year-Experience at Dominican University of California (DUC), has been

29 David Christian, "What is Big History?," *Journal of Big History*, Vol. I, No. 1 (Fall 2017), p. 4.

30 Craig Benjamin, Esther Quaedackers, and David Baker (eds.), *The Routledge Companion to Big History* (London and New York: Routledge, 2020), p. 246.

31 Fred Spier, "Thresholds of Increasing Complexity in Big History: A Critical Review," *Journal of Big History*, Vol. 5, No. 1 (May, 2022), p. 55.

32 Spier, "Thresholds of Increasing," pp. 55-56.

33 David Christian, "'The keen longing for unified, all-embracing knowledge': Big History, Cosmic Evolution, and New Research Agendas," *The Journal of Big History*, Vol. III, No. 3 (Jul., 2019), pp. 3-18.

34 Spier, "Big History is not an all-encompassing world view," pp. 3-5.

35 Eric J. Chaisson, "The Natural Science Underlying Big History," *Scientific World Journal*, Vol. 2014 (2014), pp. 1-41; Eric J. Chaisson, "Practical applications of cosmology to human society," *Natural Science*, Vol. 6 (Jun., 2014), pp. 767-796; Eric J. Chaisson, "Big History's Risk and Challenge," *Expositions*, Vol. 8, No. 1 (2014), pp. 85-95, reprinted in *Origins*, Vol. IV, No. 11 (Nov., 2014), pp. 6-13. For a gps, see David Blanks, "Rocket Science: Big History and Cosmic Evolution: A review of some recent papers by Eric Chaisson," *Origins*, Vol. IV, No. 11 (Nov., 2014), pp. 14-16; and Fred Spier, "Response to Eric Chaisson's Big History's Risk and Challenge," *Origins*, Vol. IV, No. 11 (Nov., 2014), pp. 17-20.

36 Yuval Noah Harari, *Sapiens: A Brief History of Humankind*, translated by Yuval Noah Harari, John Purcell, and Haim Watzman (London: Vintage Books, 2014). Review by John R. Pfeiffer, *Utopian Studies*, Vol. 28, No. 1 (2017), pp. 215-216.

37 Yuval Noah Harari, *Sapiens: A Brief History of Humankind* (London: Harvill Secker, 2014). Yuval Noah Harari, *Sapiens: A Brief History of Humankind* (New York: Vintage Books, 2014). Yuval Noah Harari, *Homo Deus: A Brief History of Tomorrow* (London: Harvill Secker, 2016). Yuval Noah Harari, *Homo Deus: A Brief History of Tomorrow* (New York: Vintage Books, 2016). Yuval Noah Harari, *21 Lessons for the 21st Century* (London: Jonathan Cape, 2018). Yuval Noah Harari, *21 Lessons for the 21st Century* (New York: Vintage Books, 2018).

38 Jouni-Matti Kuukkanen (ed.), *Philosophy of History: Twenty-First-Century Perspectives* (London and New York: Bloomsbury Academic, 2021), p. 210.

discontinued. The Big History Institute at Macquarie University, Australia, where David Christian used to chair, is now disbanded. Only in Asia, has big history been sturdy and growing, thanks to the effort of Barry Rodrigue of the Symbiosis International University in Pune, Maharashtra, India, Hirofumi Katayama and Nobuo Tsujimura of J.F. Oberlin University, Tokyo, Japan, and Ma. Rubeth R. Hipolito of the Holy Angel University (HAU), Angeles City, Philippines.[39]

But is big history simply a materialist account of increasing complexity mediated by energy flows? Or is it something **more** than that? Over the years, I have felt increasingly dissatisfied with the cartography metaphor ("Maps of Time" in David Christian's jargon; I feel big historians should be authentic knowers and guides to human evolution, engaged keepers of humanity in this age of fleeting technology void of anchor, mis/disinformation and increasing listlessness.[40] I feel if big history is to move forward, it has to receive adequate criticism and reinvent itself. That was why I uttered the following call in my own review of big history:

> Now, with an array of big history publications in place, with the formation of the International Big History Association (2010), biennial meetings in 2012, 2014, 2016, and 2018 (the planned 2020 IBHA Congress at Symbiosis University in West Bengal, India, was postponed for one year as a result of the COVID-19 pandemic), the creation of the Big History Project (2012) supported by Bill Gates and involving hundreds of schools offering courses in big history, the publication of the textbook, *Big History: Between Nothing and Everything* (2014), coverage in the *New York Times*, the *Times of London*, and elsewhere, and the publication of the scholarly *Journal of Big History* beginning in 2017, it is high time big history were criticized, deconstructed, and improved upon.[41]

It is not at all surprising Hirofumi Katayama of Japan exclaimed that he has "long been dissatisfied with mainstream Big History, as represented by David Christian and other's text, *Big History: Between Nothing and Everything* (2014), and Fred Spier's *Big History and the Future of Humanity* (2015)," "primarily because of their anthropocentric and modernistic characteristics." And when he tries "to apply Big History to today's global problems," he finds it "difficult for mainstream Big History to critically understand and offer clear solutions to the problems of the Anthropocene."[42] And his aim, in writing this paper, is to introduce Wang Dongyue's version of Big History, which was in turn built on the ancient Chinese Taoist philosophy of Laozi, especially his "doctrine of weakness."[43]

My own criticism of big history is that it transcends humanity to discover humanity, but it does it half-heartedly, with little room for non-materialistic or human spiritual pursuit, to the point of denying any such possibilities; or in the words of Ian Hesketh, "[b]ig History privileges the cosmic at the expense of the human, the natural at the expense of the political."[44] More recently, I have

39 I am grateful to Nobuo Tsujimura for reminding me of the unique role played by the late Luis Calingo (1955-2021) in promoting big history both at DUC and HAU. Luis Calingo was Provost at DUC when big history was launched. Later he returned to his home country, the Philippines, and became President of HAU. Then he delivered its teachers to the 2017 summer institute of Big History at DUC. That was the starting point of Big History program at HAU.

40 The late Georg G. Iggers (1926–2017), whom I had been lucky enough to know and who gave the English name to our *Quanqiushi pinglun* [Global History Review (since 2008 –)] at CNU, confessed that he had been "an engaged intellectual" throughout his "entire adult life …" See Georg G. Iggers, "Afterword: The Historian as an Engaged Intellectual: Historical Writing and Social Criticism – A Personal Retrospective," in *The Engaged Historian: Perspectives on the Intersections of Politics, Activism and the Historical Profession*, edited by Stefan Berger (Oxford and New York: Berghahn Books, 2019), p. 277.

41 Sun, "Big History."

42 Hirofumi Katayama, "Wang Dongyue's Weakening Compensation: An Asian Approach for Big History," *Journal of Big History*, Vol. VI, No. 1 (2023), p. 33.

43 Katayama, pp. 33-34.

44 Sun Yue, "Transcending Humanity to Discover Humanity? A Critique of Big History," *Shixue lilun yanjiu* [Historiography Quarterly], No. 4 (2012), pp. 49-59; Sun Yue, "The Para-Transcendence of Big History," *Shixue jikan* [Collected Papers of History

reformulated my criticism as follows:[45]

> Big history's ambition of clarifying the fate of humanity from the larger perspective of cosmic evolution has added interesting insights to the study of history. Also, big history has the merit of stringing together all disciplines of human knowledge for the making of a modern creation myth. But big history has its limitations. As it stands, it is not exactly an awe-inspiring story, for at root it says that humanity is a product of stardust, that it has come, and that it will go away—not very much to soothe the "existential angst" that many acutely feel today. David Christian's "collective learning" has need to be more concretized. Fred Spier's "principle of tracing energy flows through matter within certain Goldilocks boundaries" seems to be saying everything when in fact it says little.[46]
>
> Essentially, big history in its current form lacks what is needed if it is to be of more, and longer-lasting, appeal to readers of history. As "arbiters of our own fate," we, "the editorial board of life on earth,"[47] cannot hope to achieve sustainability if we do not even provide for a modern creation myth of sustainability for humanity. Akop Nazaretyan acquired, as a small child, the notion that "only the death of humankind as a whole could result in an individual's death."[48] That is the logic behind human sustainability on Earth, or even beyond Earth, if humanity make it into the future: each and every one of us is locked in a package of science, love, law, and order; even if we perish in the end, we perish with a distinction.

A Big History of Science, Love, Law, and Order

A big history of my own

"Science, love, law, and order" – over the past few years I have been working on these four key concepts, and possibly in coming years I will continue to do so, for I have come to believe that

> For humanity in the universe, history is nothing but the playing out of a few essential ideas, i.e., science, love, law, and order. … Science means genuine knowledge of the world and being human; love is where the meaning of being human resides (formerly administered successfully by traditional religions for longer periods that we can imagine); obeying laws derived from the above (science and love) or even formulating rituals to facilitate law-abiding abilities naturally follows; and the end result of all this is order, a humane scheme in conformity with our perceived natural order, this last one coming very close to the traditional Chinese concept of "unity of Heaven and humanity."[49]

These key concepts are not randomly selected, but are the very essential qualities of being human, the distillation of a lifetime of reading, reflecting, crystalizing, meditating, on issues of the import of human civilizations. For, without science, in its primary sense of "knowing" or "knowledge"

Studies], No. 1 (2019), pp. 21-27; Ian Hesketh, "What Big History misses," Aeon, 16 December 2021, https://aeon.co/essays/we-should-be-wary-about-what-big-history-overlooks-in-its-myth, accessed August 28, 2023.

45 Sun, "Big History."

46 The late global historian Bruce Mazlish (1923-2016) has a really harsh word for Fred Spier's *The Structure of Big History: From the Big Bang until Today* (Amsterdam: University of Amsterdam Press, 1996), saying: "The overall schema fails to impress. It is pretentious rather than persuasive. Its effort to provide a single, all-encompassing theoretical framework is unsuccessful, and its principle of regimes, empty. It is, therefore, in spite of its overarching ambitions that the book emerges as worth reading, a small primer on some of what happened between the big bang and today." See Mazlish, "Big Questions? Big History?," pp. 232-248, quote on p. 245.

47 John R. McNeill and William H. McNeill, *The Human Web: A Bird's-Eye View of World History* (New York: W.W. Norton, 2003), p. 323.

48 Akop Nazaretyan, "A Quest for Immortality," in *From Big Bang to Galactic Civilizations, A Big History Anthology*, Vol. II: *Education and Understanding, Big History around the World*, eds. Barry Rodrigue, Leonid Grinin, and Andrey Korotayev (Delhi: Primus Books, 2016), p. 177.

49 Sun Yue, "An Interview with Yuval Noah Harari," *Xinjingbao* [The Beijing News], May 13, 2017, p. B05; Sun Yue, "An Interview with Yuval Noah Harari," *International Journal for Transformation of Consciousness* (India), Vol. 3, No. 1 (2017), p. 281.

– instead of its contemporary meaning of reductionist or even falsificationist knowledge, although these are often regarded as the surest knowledge that we have – we are left with nothing but chaos and darkness. I say science in this way because that is the way knowledge and/or wisdom actually *is*, especially from the perspective of comparative cultural or civilizational studies. Without love, in the sense of genuine concern among people (indeed, why should we?), we are left not only being forlorn and sad, but also purposeless and aimless. Without laws, both natural and human-made, and their accompanying rituals, we are barely a heap of loose sand. Without the right order(s), and of course, adequate comprehension of the right order(s), either cosmic, planetary, global, or intercivilizational, intercultural, international, interregional, interpersonal, we run immediately into chaos, to the point of threatening each other with the most deadly weapons we have.

A few years ago, I composed a short piece on the Tao of big history in Chinese traditions,[50] tracing the contour of the "unity of Heaven and humanity" in Chinese historiography, especially in connection with the changing connotations of "Tian" (Heaven or *ziran*[51]). At the Villanova University-hosted 2018 International Big History Association conference, I asked the question "Is there such a thing as love in big history?," which was published two years later as a paper in a Chinese publication.[52] In it, I discovered the following answers: Eric Chaisson says Not me, it's none of my business! Fred Spier would say No! For love makes science soft and is to be avoided at all costs. Only the Cosmos ticks, with energy rate density. David Christian is somewhat hesitant: Well, maybe, when there is the fateful slip from "Is" to "Ought". I myself say a big Yes to Love, arguing that it is Love that brings meaning to the whole big history story and humanity. Then it proceeds to discuss the respective mechanisms for bringing love to humanity in Confucianism and Christianity, focusing on the frameworks of both traditional Chinese "big history" and the modern big history.

An example and invitation to contribute likewise

I promise to write more on this chain topic, on law and order in particular. And in doing so, I strongly wish that scholars from other cultures and civilizations would pose their own ultimate questions on being human and provide their own answers, for these constitute big historically significant issues proper. In other words, my own interest in big history is partly shaped by my own understanding of the Chinese effort to construct a humanized world. In trying to achieve this, the Chinese Taoist thinking comes closest to our big history vision, i.e.,

> A Way that can be followed is not a constant Way.
> A name that can be named is not a constant name.
> Nameless, it is the beginning of Heaven and earth;
> Named, it is the mother of the myriad creatures. (Chapter 1)[53]

This showcases the Chinese perception of the beginning of the world from a non-reductionist perspective: there is no "Big Bang" here, only the metaphor of regeneration.

> In the universe are four things that are great and the true king is first among them.
> People model themselves on the earth.
> The earth models itself on Heaven.

50 Sun Yue, "The Tao of Big History: The Chinese Traditions," in *From Big Bang to Galactic Civilizations: A Big History Anthology*, Vol. 1: *Our Place in the Universe: An Introduction to Big History*, eds. Barry Rodrigue, Leonid Grinin, and Andrey Korotayev (Delhi: Primus Books, 2015), pp. 223-234.

51 For a most recent elaboration, see Yueqing Wang, Qinggang Bao, and Guoxing Guan, *History of Chinese Philosophy Through Its Key Terms*, translated by Shuchen Xiang (Singapore: Springer/Nanjing: Nanjing University Press, 2020), pp. 233-241.

52 Sun Yue, "Is There Such a Thing as 'Love' in Big History?," *Shijie lish pinglun* [The World Historical Review], No. 3 (2020), pp. 215-236. Sun Yue, "Big History," in *Bloomsbury History: Theory and Method*, eds. Q. Edward Wang (London: Bloomsbury, 2021). Sun Yue, "Big History and Little Big History," in *Quanqiushi gailun* [A Introduction to Global History], edited by Liu Wenming (Beijing: Beijing University Press, 2021), pp. 367-394.

53 Philip J. Ivanhoe and Bryan W. Van Norden, (eds.) *Readings in Classical Chinese Philosophy* (New York and London: Seven Bridges Press, 2001), pp. 157-201, p. 159. For an interesting elaboration on the mysterious birth of the myriad of things out of non-being, see Liu Xiaogan, "The Notion of *Wu* or Nonbeing as the Root of the Universe and a Guide for Life," in *Nothingness in Asian Philosophy*, edited by JeeLoo Liu and Douglas L. Berger (London and New York: Routledge, 2014), pp. 151-165.

Heaven models itself on the Way.
The Way models itself on what is natural. (Chapter 25)[54]

The Way produces the One.
The One produces two.
Two produces three.
Three produces the myriad creatures. (Chapter 42)[55]

Following the Way of the world, the Confucianists were in turn formulating and regulating "all under Heaven" to make for an orderly human society:

> The ancients who wished to illustrate illustrious virtue throughout the kingdom, first ordered well their own states. Wishing to order well their states, they first regulated their families. Wishing to regulate their families, they first cultivated their persons. Wishing to cultivate their persons, they first rectified their hearts. Wishing to rectify their hearts, they first sought to be sincere in their thoughts. Wishing to be sincere in their thoughts, they first extended to the utmost their knowledge. Such extension of knowledge lay in the investigation of things.
> Things being investigated, knowledge became complete. Their knowledge being complete, their thoughts were sincere. Their thoughts being sincere, their hearts were then rectified. Their hearts being rectified, their persons were cultivated. Their persons being cultivated, their families were regulated. Their families being regulated, their states were rightly governed. Their states being rightly governed, the whole kingdom was made tranquil and happy.[56]

The parties, each in their proper realms, undertake what are proper for themselves. One finds in individuals, for example, the pursuit of knowledge and love (complete knowledge, sincerity, and cultivated persons), and of law and order in regulated families and states and a peaceful world. Or in another syncretic pronouncement in the Doctrine of the Mean,

> What Heaven has conferred is called the Nature; an accordance with this nature is called the Path of duty; the regulation of this path is called Instruction.[57]

The appeal of the family is so great to the Chinese that it is almost impossible for them to think outside it, so that a millennium and more later, the Chinese philosopher Zhang Zai (1020-1077) was still constructing his meaningful world in terms of the family:

> Heaven is my father and Earth is my mother, and even such a small creature as I finds an intimate place in their midst.
> Therefore that which fills the universe I regard as my body and that which directs the universe I consider as my nature.
> All people are my brothers and sisters, and all things are my companions.[58]

And the grand synthesis of the "unity of Heaven and humanity," even up to today, is still considered as the highest ideal that the Chinese hold for this world, i.e., a state of "Grand Harmony," as articulated by Confucius through philosopher Fung Yu-lan:

> When the great Tao was in practice, the world was common to all; men of talents, virtue and ability were selected; sincerity was emphasized and friendship was cultivated. Therefore, men did not love only their own parents, nor did they treat as children only their own sons. A competent

54 Ivanhoe and Van Norden, p. 171.
55 Ivanhoe and Van Norden, p. 180.
56 James Legge, *The Chinese Classics*, Vol. I: *Confucian Analects*, *The Great Learning*, *The Doctrine of the Mean* (Hong Kong: Hong Kong University Press, 1960), pp. 357-359. James Legge, *The Chinese Classics*, Vol. I: *Confucian Analects*, *The Great Learning*, *The Doctrine of the Mean* (Oxford: The Clarendon Press, 1893), pp. 357-359.
57 James Legge, *The Four Books in Chinese and English*, revised and annotated by Liu Zhongde and Luo Zhiye (Changsha: Hunan Press, 1992), pp. 24-27.
58 Chang Tsai (Zhang Zai), "The Western Inscription," in *A Source Book in Chinese Philosophy*, trans. Wing-tsit Chan (Princeton, N.J.: Princeton University Press, 1963), p. 497.

> provision was secured for the aged till their death, employment was given to the able-bodied, and a means was provided for the upbringing of the young. Kindness and compassion were shown to widows, orphans, childless men and those who were disabled by disease, so that they all had the wherewithal for support. Men had their proper work and women their homes. They hated to see the wealth of natural resources undeveloped, [so they developed it, but this development] was not for their own use. They hated not to exert themselves, [so they worked, but their work] was not for their own profit …. This was called the great unity.[59]

And the highest aspiration for any genuinely serious Chinese scholar, in the words of China's Song Dynasty gentry-scholar Zhang Zai (1020–1077), is to help facilitate "establishing the mind of Heaven and Earth, determining the destiny of human lives, restoring discontinued traditions of learning from the past, and commencing a period of supreme peace for one's descendants."[60]

Essentially, these programed messages are the architectural foundation of the Chinese civilization; when and if duly observed, these led to an "ultrastability" of the Chinese imperial grandeur though "the underlying structure focused on 'administrative security' rather than enhancing the welfare of the people."[61] Yet when operating at its maximum, it sees no match in terms of both efficiency and orderliness:

> The coming into shape of a historical economic scenario is a long and natural process of following the bodings of Heaven and the patterns of time. Sima Qian the grand historian of two millennia ago made it very clear: The common run of people come to and fro driven by the lure of profit; they get what they desire based on their competence and strivings. This is as natural as water flowing downward, night after day; there is no rush for it, for it will come to you if you are least demanding. Therefore, those who are real wise simply let it be; next come those who would channel it; still next, those who would cultivate and regulate the people; and the least wise are those who would battle for it! The economic growth of South China ultimately surpassing that of North China in later times, turning the south into a "land of bustling prosperity and propriety," is full testimony of the predictive validity of Sima Qian's "principles of economy."[62]

In 1987, Liu Zaifu, the irksome Chinese cultural critic, wrote a harsh criticism on the complementary Chinese Confucian and Daoist/Chan Buddhist "designs on humanity," denouncing the former for ritually suppressing individuality through coercive norms, and the latter for relinquishing of will and desires from within. Liu champions a thoroughgoing humanism to counter the ritual order's deep-rooted master-slave disposition, egocentric focus on kinship, selfish departmentalism, and enslavement to status and "face." For Liu, personal and national self-renewal depend on individual initiative and respect for

59 Yu-lan Fung, *A Short History of Chinese Philosophy*, trans. Derk Bodde (New York: Macmillan, 1948), pp. 202–203.

60 Zhang Zai, in Zhang Liwen, 'Establishing the Mind of Heaven and Earth', *Guangming ribao* (Guangming Daily), 19 December 2016, p. 2. The pithy insights of Zhang Zai have been shared by later generations of Chinese scholars and civil servants, including President Xi Jinping. When I mentioned this to Yuval Harari, however, he denounced that as "fantasies about a past that never existed," and cautioned that "we should be very careful not to fall prey to nostalgic delusions." This is cross-culturally unfair; for it is not exactly an utopian dream, and if the Chinese are truly enamored of this ideal and find ways to faithfully implement it on earth, it will be a true blessing onto the world. See Sun Yue and Yuval Harari, "Scholarly Exchange: Human Civilization Calls for a New Story to Bolster," *Xin jing bao* [The Beijing News], May 13, 2017, p. B05; Sun Yue, "An Interview with Yuval Noah Harari," *The International Journal for Transformation of Consciousness* (India), Vol. 3, No. 1 (Jun., 2017), pp. 282-283. Interested readers can turn to Ralph G. H. Siu, "Panetics the Study of the Infliction of Suffering," *Journal of Humanistic Psychology*, Vol. 28, No. 3 (Jul., 1988), pp. 6-22; and his *Less Suffering for Everybody. An Introduction to Panetics* (Washington, DC: International Society for Panetics, 1993) for a taste of what a leading scientist of Chinese cultural descent is leading up to.

61 Børge Bakken and Jasmine Wang, "The changing forms of corruption in China," *Crime, Law and Social Change: An Interdisciplinary Journal*, Vol. 75, No. 3 (Apr., 2021), p. 248.

62 Wang Jiafan, "'The Chinese Wisdom' Must Be Sought from Its History," *Shehui kexue bao* [Social Sciences Weekly], April 28, 2016, p. 8.

human dignity and equality.[63]

Things to Do to Improve

The above section serves to illustrate this author's vision of big history, plus an example of the Chinese civilizational pattern. The gist of it is: big historically, the Chinese have pursued their vision of being human based on their own package of "science, love, law, and order," so to speak. It is one among a multitude of human civilizations. If more scholars from all human civilizations can step forward and share their own visions, our big history movement will be greatly enriched, and perhaps grow substantially as a result of this synergy of communication and dialogue.

Now I'd like to suggest a list of possible topics to be addressed by big historians in the future, or topics as I see fit for a big history treatment.

First, the problem of authority or expertise in knowledge integration or synthesis. In dealing with knowledge of the big history scale, no one can claim authority on all things. That's why, at this moment, successfully transdisciplinary scholarship is highly valued. Nasser Zakariya's *A Final Story: Science, Myth, and Beginnings* (Chicago, IL: University of Chicago Press, 2017), highly reviewed and recommended by Ken Baskin,[64] is a case in point. My suggestion is to welcome scholars of all disciplines or even non-scholars (persons deeply versed in whatever non-accredited learning or art, *fengshui*, for example) to join in the big history construction, including religionists of sorts. To be honest, I was not at all surprised to find so many religionists or even those fervent about setting up a "Big Religion" for all earthlings when I attended the first and second IBHA at Grand Valley State University and Dominican University respectively in 2012 and 2014. AI might help, but it has to learn to treat knowledge in a humanely significant way.

Second, the traditional Chinese thesis of "unity of Heaven and humanity." In Tu Weiming's understanding, this embodiment of the universe encompasses the beginning and end of the Confucian "self-realization," to borrow a Western notion of the ultimate human pursuit.[65] The noted Chinese historian Qian Mu (1895-1990) of Taiwan, shortly before he died, and in fact in his last essay, singled this out as a possible contribution that Chinese culture can hopefully make to the world. Exactly the same conclusion was independently reached by two other eminent Chinese scholars around the same time, Tang Junyi (1909-1978) of Hong Kong, and Feng Youlan (1895-1990) of Beijing. This oneness of self with others and the totality of things under Heaven or in the whole of universe is a genuine big history topic that merits serious study in the future.[66] This pursuit of the oneness of Heaven and humanity, i.e., the categorical overlapping of cosmology, worldview and human aspirations I suspect, is exactly what the late William H. McNeill had in mind when he was praising David Christian for his unique contributions to big history.

Thirdly, the root of the human feeling of love, the family. Yanming An describes a "natural affection that universally exists in human life," i.e., within the human family, on the basis of which classical Confucianism develops a system of moral imperatives, which takes an all-embracing attitude toward humans in the world, viewing all of them as members of the same moral community, achieving universal caring in principle and real life.[67] In comparison, it takes Godly commandments to realize universal love in

63 See *Liu Zaifu: Selected Critical Essays*, edited by Howard Y. F. Choy and Jianmei Liu (Leiden: Brill, 2021), pp. 119-133.

64 Nasser Zakariya, *A Final Story: Science, Myth, and Beginnings* (Chicago, IL: University of Chicago Press, 2017). Nasser Basem Zakariya, "Towards a Final Story: Time, Myth and the Origins of the Universe," PhD dissertation, Harvard University, 2010. Ken Baskin, "A Cosmological Crisis?: A Review of Nasser Zakariya, *The Final Story: Science, Myth, and Beginnings*," *Journal of Big History*, Vol. III, No. 4 (Oct., 2019), pp. 171-176. Zakariya's *A Final Story*, however, mentions "big history" only once.

65 Tu Wei-ming, "Embodying the Universe: A Note on Confucian Self-Realization," in *Self as Person in Asian Theory and Practice*, ed. Roger T. Ames, with Thomas P. Kasulis and Wimal Dissanayake (Albany, NY: SUNY Press, 1994), pp. 177-186.

66 See Qian Mu, "A Contribution Chinese Culture will Make to the Future of Mankind," *Zhongguo wenhua* [Chinese Culture], No. 1 (1991), pp. 93-96; Tu Weiming, "The Ecological Turn in New Confucian Humanism: Implications for China and the World," *Daedalus*, Vol. 130, No. 4, Religion and Ecology: Can the Climate Change? (Fall, 2001), pp. 243-244. For a Western elaboration on similar thoughts, see Philip J. Ivanhoe, *Oneness: East Asian Conceptions of Virtue, Happiness, and How We Are All Connected* (Oxford and New York: Oxford University Press, 2018); Victoria S. Harrison, "Oneness: A Big History Perspective," in *The Oneness Hypothesis: Beyond the Boundary of Self*, eds. Philip J. Ivanhoe, et al. (New York: Columbia University Press, 2018), pp. 39-52.

67 Yanming An, "Family Love and Its Extension: A Comparative Evaluation," in *New Life for Old Ideas: Chinese Philosophy in the*

Christianity and other monotheistic religions. Rather handy and core examples are:

> Jesus replied, "This is the most important: 'Hear O Israel, the Lord our God, the Lord is One. Love the Lord your God with all your heart and with all your soul and with all your mind and with all your strength.' The second is this: 'Love your neighbor as yourself.' No other commandment is greater than these."(Mark 12: 29-31, NIV)
> "He answered, 'Love the Lord your God with all your heart and with all your soul and with all your strength and with all your mind' and, 'Love your neighbor as yourself.'" (Luke 10: 27, NIV)

Now, with family and home in crisis in East and West, North and South,[68] where do we turn to for such humanely feelings? This really troubles me, and the whole world. Without God or family/home, who really cares? Does "Big Religion" have Someone or Some Institution to whom I can place my heart and trust?

Fourthly, do the Chinese have something uniquely helpful to the world? My answer is certainly a Big Yes!, since the Chinese vision is holistic, process-and-relation-based, harmony-and-balance-oriented, serving as a useful alternative to the reductionistic modern science. In his paper, Hirofumi Katayama describes his "vision of Asian Big History based on Wang Dongyue's weakening compensation theory" as "relation-oriented, altermodern, and non-anthropocentric."[69]

Fifthly, possibly as a model case of the above penchant, ***the Traditional Chinese Medicine***, often abbreviated as TCM. TCM is based on uniquely Chinese philosophy and yields concrete therapeutic effects. Concerning this, I have very intimate experiences, with all my beloved receptive to TCM. It works for them. Big History claims that it is built on the surest foundation of modern sciences, but the monopolizing modern sciences often relegate everything that's alien to it as superstition, or at least something fishy, unfit to be trusted, like the TCM.[70] I will certainly work more on this topic, and it is indeed history that's still in the making.

Sixthly, it is a pleasant though somewhat surprising fact that big history's most enthusiastic fans are a group of scholars who call themselves ***literary anthropologists*** headed by the eminent Chinese scholar Ye Shuxian. These scholars usually pair David Christian (for his styling big history as "modern creation myth") and Yuval Harari (especially in connection with his featuring humanity as a "storyteller" species), for they want to prove that the ancient Chinese practice of jade worship gave rise to much of Chinese cultural history,[71] thus extending further back by several thousand years the origin of the Chinese civilization.

There are certainly many more such sparkling inspirations, but I can only share the above as they came

Contemporary World: A Festschrift in Honour of Donald J. Munro, eds. Yanming An and Brian J. Bruya (Hong Kong: The Chinese University Press, 2019), pp. 367-392.

68 Eva-Sabine Zehelein, Andrea Carosso, and Aida Rosende-Pérez (eds.), *Family in Crisis? Crossing Borders, Crossing Narratives* (Bielefeld: transcript Verlag, 2020), pp. 9-23. For a brief overview on related concern and research in China, see Sun Xiangchen, "Reestablishing the Significance of 'Family' in the Modern World," translated by Xu Qingtong, *Contemporary Social Sciences*, No. 4 (2020), pp. 44-59. For more detailed studies, see Yang Xiaosi, *A Philosophy of Home: Blind Spot of Westerners* (Beijing: The Commercial Press, 2010); Wu Fei (ed.), *The Holy Home: A Comparative Study of Chinese and Western Civilizations* (Beijing: Religious Culture Press, 2014); Zhang Xianglong, *Home and Filial Piety: From Chinese and Western Perspectives* (Beijing: SDX Joint Publishing Co., 2017); Liang Shuming, *Fundamentals of Chinese Culture*, trans. Li Ming (Amsterdam: Amsterdam University Press, 2021), etc.

69 Katayama, p. 39. The same issue has another article on Wang Dongyue by an aspiring young Chinese scholar, see Ye Chen, "The General Law of Being. Article 1: Being of Interrelation. Journal of Big History," *Journal of Big History*, Vol. VI, No. 1 (2023), pp. 47-62. Ye Chen promises a trilogy of three articles, the second of which is also published, see Ye Chen, "The General Law of Being. Article 2: The Being of Differentiation and Its Arising Issues," *Journal of Big History*, Vol. VI, No. 2 (2023), pp. 47-64.

70 For a brief overview, see Jin Qiupeng, "Ancient Sci-tech Accomplishments of the Chinese: TCM with Its Own System," in *A History of Ancient Chinese Culture*, eds. Yin Falu and Xu Shu'an, Vol. 3 (Beijing: Beijing University Press, 1991), pp. 219-223.

71 For a more recent piece, see Shuxian Ye, "Jade Worship: The Primitive Belief Systems of Chinese Civilization," in *A Mythological Approach to Exploring the Origins of Chinese Civilization*, translated by Hui Jia and Jing Hua (Singapore: Springer, 2022), pp. 173-198.

along in my brain. It's reassuring somebody is talking about "Big History 2.0."[72] In fact, a most recent *Journal of Big History* contributes a special issue on Big History Periodization, which promises to "reconsiders big history fundamentals," such as "periodization"[73], and the succeeding issue – *JBH*, Vol. VII, No. 1 (2024) – more, such as the "problem with the concept of complexity", "free energy rate density" as complexity metric, and the "master plot of energy rate versus mass for a very wide variety of (complex) systems."

Now a brief recap. The further growth of big history calls for both contributors and critics. This is decided by its all-inclusive nature – requiring all human knowledge, and its pan-human concern – calling for locally-sensitive action apart from rigorous logic, both of which are often beyond the capabilities of individual authors. So far, Big History has received less than desirable constructive criticism; but the good thing is that more and more big historians are increasingly self-reflective and self-criticizing in an effort to improve. This essay is a call on more and more scholars from various cultures and civilizations to step forward and to contribute, by reflecting on their own civilizational contours, with the ultimate end of throwing all of us into a grand big historically significant cross- or trans-civilizational dialogue. My own formula of "science, love, law, and order" for evolving humanity in the context of an expanding universe is this: Tell us the truth, spread love among people, truthfully follow the rules we concede to, build an order that can last. This way, we won't regret even if we die. For this is the human lot.

The Chinese wisdom of living in this finite world of inconstancy is usually credited with that of *Yijing* or *The Book of Changes*, in a signature, as follows:

> Because the universe is an open system that is self-generative and self-transformative, we must live with ceaseless change; Because changes take place all the time, we must find ways to understand their patterns and to navigate their complexity; In every moment, we must be ready to make difficult decisions in order to find peace and comfort in life.[74]

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72 I am happy to find that more and more big historians are conscientiously applying their own expertise and taking advantage of various forms of collaboration to advance basic theories of big history research. See, for example, Gregg Henriques and Tyler Volk, "Toward a Big History 2.0: A brief position paper," *Journal of Big History*, Vol. VI, No. 3 (Nov., 2023), pp. 1-4.

73 Henriques and Volk, p. i.

74 Tze-Ki Hon, "Chinese Philosophy of Change (*Yijing*)," in *The Stanford Encyclopedia of Philosophy* (Fall 2023 Edition), eds. Edward N. Zalta & Uri Nodelman, https://plato.stanford.edu/archives/fall2023/entries/chinese-change/, accessed February 4, 2024.

The General Law of Being, Article 3: The Ultimate Cause of Evolution

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This is the third article in a series about the General Law of Being, a science philosophy that was introduced by Chinese scholar Wang Dongyue twenty years ago and then expanded upon by Chen Ye, who linked it to other scientific and philosophical traditions as well as to Big History. We encourage readers to review the previous two articles in the *Journal of Big History*, volume 6, issues 1 and 2.

Article 1 addressed how all entities in the universe – 'beings' – are finite and dependent. Horizontally, their existence is realized through the structural coupling of their *interactive-quality* with other being(s)'s *interactable-quality*, and vertically through the superposition of their historical *structural-coupling* states. Article 2 reveals the interplay of the two opposite forces that govern evolution – conservation and variation. This evolution / variation progress occurs through the differentiation of beings, level by level – each level of organization results from differentiation of beings at a lower level of organization, with the 'adaptation task' distributed to specialized roles at higher levels.

However, this ascent comes with a trade-off – the existence of a higher-level being depends on an increasing number of conditions. These conditions not only facilitate its functioning but also expose it to greater risks, which means that higher-level beings have weaker, or more unstable structures. Meanwhile, the increasing number of conditions perplexes the sense-reaction process, giving rise to more advanced cognitive patterns to coordinate the process.

In this article, we first examine the situation of the most sophisticated 'natural' structure formed by the most complex species – human society, by applying the fundamental principles discussed in Articles 1 and 2. We then systematize various clues in macro-evolution and based on theories previously outlined, we build our model of evolution to address the ultimate driving force behind evolution.

The Formation of Society

The conditions-of-existence of higher-level species is reflected through the forms of their society. Society is not an invention of a species but is instead an essential product of the evolutionary process. As predators that fed on unicellular prey emerged, single-celled organisms had to increase their size to avoid predation, so a practical means to achieve this growth was through aggregation and cohesion. In experiments that introduced predators among green algae (a prokaryote), the algae evolved into multi-cellular groups. This highlights a tendency of living organisms to develop 'social structures' in response to survival pressures.

Because of relatively low survival pressure, prokaryotes typically did not form complex social structures since their rapid reproduction and versatile metabolism endowed them with a stable existence as individual cells. But as the structure of some of them began to differentiate into single-celled eukaryotes, these new living-beings faced new pressures and further adapted. This transformation mainly came about from three situations:

A. Metabolism became more complex as larger organisms needed high-energy sources to maintain their nutritional equilibrium. This increased their challenge to acquire sufficient food. The problem was resolved through grouping, by which constituent members collaborated for nourishment, ensuring satisfaction of individuals. This serves as the earliest form of an *economic mechanism*.

B. Reproduction and care for individuals was more demanding among higher-level species. It gave rise to consanguineous communities to enhance bonds of interdependence between members of a lineage, including between genders, offspring, and age-groups. This cultivation of inheritance resulted in resource allocation and emergence of a *political mechanism* in larger related groups.

C. Sensation and reaction became more complex. Sensory / motor organs and a nervous system were strengthened for an organism to make better decisions when facing different situations. Living-beings network themselves into a *sensorimotor net* that integrated information and coordinated reactions. This gave rise to an *intercommunication mechanism* (cultural phenomenon).

The formation of society is not so very different from the formation of a multi-cellular organism. While an organism consists of the interior aggregation and differentiation of cells, **society is the exterior aggregation and differentiation of living beings.** Cells aggregate together when single cells face crisis in maintaining their existence. To form a 'cell society,' they must differentiate into various functions and link with each other to maintain the stability of a 'social structure' – multicellularity.

Competition arose from the pressures described above, and from other challenges, which stimulated further complexification of organisms, by natural selection, bringing about even heavier pressures for living-beings. **When an individual cannot deal with the pressures that threaten its existence, exterior differentiation and coupling is inevitable.** By grouping, individuals can make up for their 'disability' by depending on others. As a result, we can evaluate the adequacy of a species' function by its social structuration rate (Diagram 1).

A non-regulated society implies the adequate functioning of its individual members, while a well-structured society indicates inadequate functioning, which necessitates stronger bonds between individuals. The transition from a low-structured society to a high-structured society represents a shift from individual goals to community goals – altruism. Individuals in a highly-structured society relinquish a degree of self-interest and contribute to the well-being of others.

However, assessing the "superiority" of a high- or low-structured society is meaningless. What matters is only **the suitability of the social structure to the existence state of the species**. The determination of the appropriate balance between selfishness and sacrifice is naturally governed by the Evolutionarily Stable Strategy (ESS) mechanism.

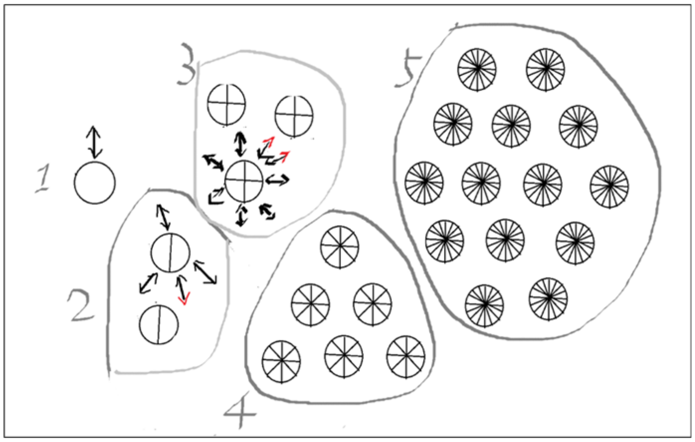


Diagram 1: This shows the formation of society as a unit's structure becomes more complex, a result of the dynamic between external conditions and individual units. The outward-pointing arrows show a unit's interactive-quality coupling with external conditions (shown as inward-pointing arrows). If external conditions are satisfied, the formation of society is unnecessary, with a unit remaining independent (item 1). If external conditions are greater than a unit's innate interactive qualities (more inward-pointing arrows than outward-pointing arrows), individuals form society to compensate for their inadequacy. This generates red arrows, which represent the gap between a units' interactive qualities and external conditions that can be satisfied by structural-coupling with other units to form society. We can imagine more and more red arrows in items 4 and 5 with the complexification of individuals, along with more external conditions that need to be satisfied. Diagram by Ye Chen.

A classic example of ESS is the *hawk-dove game*, which posits two subtypes of a species with different strategies: aggressive 'hawks' and peaceful 'doves.' Most choose a hawk strategy, since it allows access to 'easy' food from doves. But if everyone is a hawk, there is a population loss from hawk in-fighting, which hinders conservation of the species. This drives some hawks to become doves, so the ratio reaches a stationary point of two hawks to eight doves.

This implies that formation of a social structure is driven by collective biological behaviours, ultimately determined by the species' interactive qualities / structure. **The equilibrium point identified signifies the existence state of the species**, where individuals are structurally-coupled with each other. This existence state plays a crucial role in shaping the species' culture, which is passed down through generations.

Issues Aroused by the Structuration of Society

The death of individuals does not greatly impact other individuals in an unstructured 'social' framework, but the death of individuals can be devasting in a highly-structured 'society.' For example, the death of a single prokaryote does not impact prokaryote society. But when cells have differentiated and joined into more complex 'societies of cells,' in response to external pressures, these new configurations (skeletal, membrane, digestive) are essential to a new society.

Such diverse functions in complex societies necessitate coordination, enabled by the interplay of signal and conversion mechanisms, traffic networks and gene expression control – all involving myriads of molecules. Despite functional redundancy, cumulative errors of individual cells that exceed a critical threshold can lead to disintegration of an entire organism. Even if some cells remain viable before collapse, they ultimately die as the collective functionality of the cell society disintegrates. This reveals a new challenge of complexification achieved by the formation of a society.

In this social complex, the damage to some cells can cause fluctuations that may reverberate through the entire organism. Although formation of a society can alleviate increased external pressures for an individual, it then brings about new pressures for internal social structures, because, in a highly-structured society, the components are so well-coupled that each plays a significant role on which other components rely. This adds tension to the relationship between individuals. **The formation of a society does not mean elimination of survival pressure for living-beings, rather, it means a transfer of pressure from an exterior to interior source.**

As social structures and interdependent / coupling relationships are established, the collective functions / interactive-qualities of a species gain in strength and efficiency. **The degree of structuration within a society correlates with augmentation of a species' functions**. This is akin to the organization of cells within an organism that lead to enhanced functionality. For instance, predation, reproduction and decision-making presuppose sensory acuity and an ability to initiate appropriate responses, which are reinforced within the framework of a social structure.

As to a human society, the collective function of cognition is enhanced by intellectuals such as scientists, philosophers and other specialists, who can be considered vanguards of 'cognitive quality.' They help develop knowledge systems, research methodologies, universal laws, and effective models. By sharing their findings with society, the cognitive quality of the human species is strengthened. For example, visual ability is enhanced by the telescope; information processing by computational technology; food acquisition by automated machinery; and locomotion ability by mechanical transport.

Conditions for Enhanced Social Functions

Enhanced social functions cannot be realized without establishment of an economic mechanism, political process, and cultural background – they serve as inevitable and indispensable conditions to sustain social structures, ensuring that social functions can operate in an orderly and efficient manner.

Consider modern improvements in human locomotion, such as development of vehicles. This advancement necessitates not only the presence of vehicles but also an organized transportation system, streamlined manufacturing process, and regulatory guidelines, as well as infrastructures for oil extraction, refinement, pollution control and management. Each factor engenders additional interdependent requirements, forming a chain of *conditions*.

Vehicles are just one part of a milieu of enhanced social functions. **If we sort out all functions and add them up, the conditions they bring about are gigantic.** The demand to accomplish these conditions stimulates individual and social dedication to certain skills, which further enhances social functions and brings about additional conditions. This shapes positive feedback.

Under such circumstances, labour division arise to facilitate efficient operation of social functions and to satisfy the conditions on which these functions rely. Consequently, individuals deepen their specializations to fulfill their respective roles, which often decreases their self-betterment capacities. This is analogous as to how specialized cells in an organism cannot survive without other cells. This heightened interdependency among individuals leads to further structuration of society.

When structuration of a society increases, internal pressures arise, elevating complexity and risks associated with relationships between individuals. Just consider various facets of daily life: a computer for work and leisure, a cell-phone for connection to the world … food, a bed and a house that is called home. Virtually nothing we utilize is self-produced. We rely on specialized roles performed by others within society's framework.

In return, we contribute value to society by fulfilling our own distinct role, upon which other members rely. This is how a society functions to sustain its existence. The cumulative loss or disruption of some divisions of labour can lead to a breakdown in the interconnected network, which affects all members. This implies that for each level of societal structuration, there exists a corresponding minimum threshold for the degree of interrelation and cooperation among its members that must be met.

A social mechanism must be developed and improved as societal structuration deepens. This social mechanism involves all aspects of a 'social' human – cultural regulation, value systems, measures of justice, moral ethics, taboos, trading laws, and so forth. Meanwhile, a political mechanism must be established to help stabilize these systems. These principles resonate with the *Law of Techno-Humanitarian Balance*, as elucidated by historical psychologist Akop Nazaretyan.

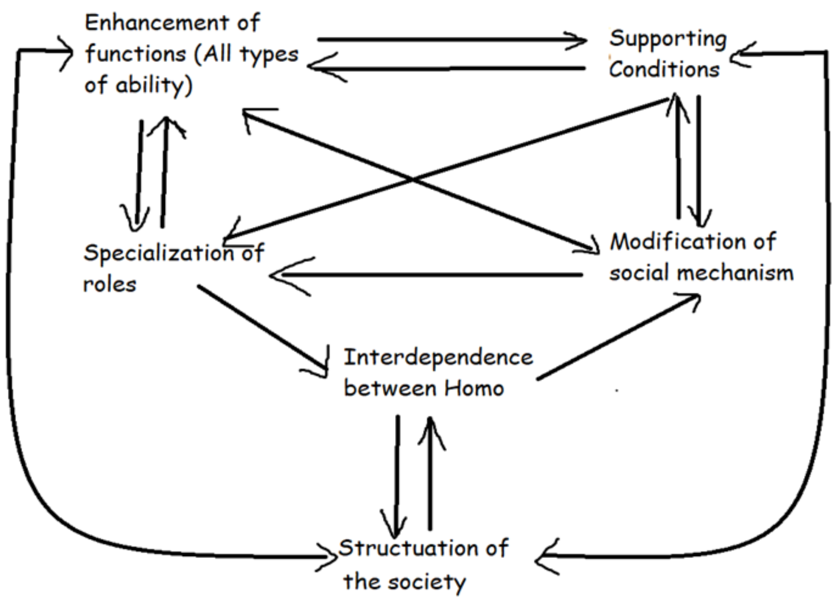


Diagram 2: Interrelated Circulatory System of Human Society. The arrows indicate promotional relationship. Diagram by Ye Chen.

Under a more advanced social system, a greater number of individuals feel secure, reducing the efforts dedicated to basic survival. The society is left with more energy that can be redirected to other endeavours, beyond survival, encouraging development of social functions / cognitive quality, such as theoretical research and technological or business innovations. We then can return to where we began, and another round of development can begin. Actually, there is no precise beginning or end in this circulatory system: **All factors are interrelated and mutually promoted, stimulating the continuous development as well as the structuration of the society** (Diagram 2).

This explains how a society evolves, why it evolves at an accelerated velocity, how it collapses, and how it can be sustained. It also explains why our knowledge about society is constantly changing. **The key lies in the accelerating growth of conditions and the enhancement of social functions**. At different evolutionary stages, human beings need to address different issues concerning increased conditions. Failure to address these conditions gives rise to internal fluctuations within the structure, manifested as conflicts, chaos or even wars, thereby posing a threat to the very existence of the social framework.

Weakening Structure

When a society reaches its highest structuration, there is maximum interactive-quality coupling with the external world, maximum conditions arise to sustain its functions, maximum connective points exist among functions, maximum specialized roles are engaged, maximum internal pressure come about, and maximum dependency exists among individuals. Errors in any of these arouse fluctuations that spread throughout the entire network.

A society in its highest structuration is at its most unstable state of existence. It is most fragile and vulnerable. This conclusion reinforces the principle addressed in Article 2: **The process of differentiation is also a process of structuration, which means more and more specialized roles are differentiated and can couple with each other to make more complex, yet weaker, structures**.

In a highly-structured society, challenges appear to be incessant, with each resolved issue giving rise to other problems. In a rapid development state, the number of emerging problems always exceed problems addressed. This is because solutions often are interdependent with conditions. They trigger a chain of social impacts, often extending to seemingly unrelated issues.

This constant influx of challenges is not a reason to depreciate the structuration tendency of society. Structuration and rapid development are a natural evolutionary product defined by the realm of existence of a species. It is owing to the unique intellectual quality ingrained in our own species that brings about rapid development as well as the capacity to engage in intricate problem-solving. While resolving a problem poses new challenges, escaping challenges means abandoning the necessary intellectual quality to sustain the state of our existence.

Some people might say that we should stop developing social functions, then no new conditions emerge, but this is a false simplicity. **The development of society is never determined by individuals but follows the mechanisms of natural selection**. The evolution of human society was determined when our ancestors diverged from chimpanzees. It was only a matter of time for this potential 'intellectual quality' to be activated, which then started the fast train of development.

But when might societal evolution come to a halt? It ceases when it has exhausted its evolutionary potential, reaching a point where human intelligence has reached its limitation or when the structural complexity of human society has reached its maximum. What characterizes a halted social structure? This is where the concept of *natural drift* comes into play.

Natural Drift and Evolutionary Potential

Evolution is a process often characterized by a transition from simplicity to complexity, but it is important to note that not all species undergo this progression. Rather, most species tend to retain their original level of organization with minimal structural variation to couple with change from the external world. This structural variation is described as *natural drift* in biologist Humberto Maturana's autopoiesis theory. Natural drift is controlled by two factors – 1) Perturbation from the external world that triggers an organism's structural change, and 2) An organism's intrinsic qualities that determine whether such change is possible.

Natural drift takes a variety of forms, such as growth of thick fur, changes in metabolism, or massive geographic migration. It also involves the selection of a degeneration of specific functions when a species no longer uses it. Molecular data has shown instances of such adaptation, as among fungi species and parasitic or anaerobic protists. They once had mitochondria, as is typical of eukaryotes, but subsequently lost them, when not needed for energy production. Moreover, many olfaction-related genes have also been lost in humans as they came to rely more on vision.

This also indicates that **every quality within an organism serves to sustain its existence, and there is nothing that is superfluous**. In other words, all interactive-qualities of a being couple with interactable-qualities. Even when a useless interactive-quality appears, it diminishes over time through natural selection.

But what if a species does not possess certain intrinsic qualities that can facilitate proper structural changes in response to external perturbations? In such cases, the species faces extinction. Organisms must work closely and synergistically with the environment. When environmental conditions shift, the prior balance of the organism is disrupted, and so the organism must initiate actions to compensate for this disrupted balance to maintain its identity. In a society where the external pressure has transitioned to internal pressure, natural drift refers to changes in response to these internal fluctuations.

This is not typically 'evolution' but instead *natural drift*. Natural drift describes how entities adapt their functions and structures in response to environmental changes, but it does not entail a substantial increase in their level of organization or interactive quality. In contrast, when we refer to evolution, we specifically mean the process that leads to a complication in the level of organization and enhancement of interactive-quality. **Both natural drift and evolution aim to achieve adaptation, but the former is more a state of fluctuation within a certain level of organization, while the latter signifies an upward trajectory in terms of organization and function**.

Beings that do not evolve but instead only engage in natural drift are considered to lack evolutionary potential. Nature is like a vast laboratory that synthesizes all possible forms of being – including non-existence (failure as a stable being), those lacking evolutionary potential, and those with evolutionary potential. Most fall within the first two categories. For instance, within the limited array of elements in the universe, only carbon atoms possess the evolutionary potential to form and progress into complex biological molecules. This is the result of their distinct characteristics, which set them apart from inert elements or unstable elements like silicon. Carbon's qualities enable it to form stable circular or chain-like compounds resistant to hydrolysis.

In a universe with ample time and space, beings that possess evolutionary potential will inevitably achieve that potential at a specific time and place, giving rise to the emergence of beings with higher-level organization. In contrast, beings with no evolutionary potential remain at their original level of organization and persist by natural drift, until a time comes when they are no longer able to respond to external perturbations or internal fluctuations.

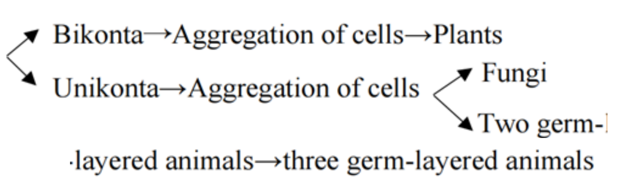
The Evolutionary Route

Our evolutionary roadmap is predicated on our definition of complexity. Complexity can be measured through various methods, and, in this context, we gauge it by considering the levels of organization that become apparent during the differentiation process. With this criterion, we can delineate the evolutionary path following the Big Bang as follows:

> Atoms → Inorganic compounds → Organic compounds → Self-replicating molecules (RNA-based catalysts or enzymes) → Prokaryotes → Eukaryotes (single-celled)

The ten-billion years following the Big Bang was an immense span of time, during which many 'division-coupling' processes had the opportunity to occur, giving rise to diverse raw materials (Diagram 3).

While the likelihood for life to evolve may have been exceedingly small, the vastness of the universe allowed for the possibility of suitable conditions for its appearance



– such as proximity to other stars, orbital trajectories, gravitational forces, and magnetic fields, as well as suitable environments with temperature range and mediums for chemical reactions. Earth is one such place, and similar conditions might well exist elsewhere in the universe.

Although we don't know exactly when it occurred in the 'division-coupling' process of the universe, organic compounds arose from the coupling of certain inorganic compounds in certain environments, as indicated in the 1952 Urey-Miller experiment. **Environmental conditions are 'interactable qualities' that coupled with the 'interactive qualities' of specific compounds to activate an 'evolutionary potential.'**

This formed primal cells / protocells, and, among them, **one that possessed the highest degree of stability was favoured by natural selection**. This entailed the selection of stable genetic and membrane materials, optimization of efficient catalytic processes, choices of cytoskeleton proteins and structure, allocation of tasks between RNA, DNA and proteins, as well as optimization of molecular mechanisms essential for functions like energy supply.[1] These attempts resulted in the formation and stabilization of prokaryotic cells along the evolutionary route 3.5 billion years ago.[2]

Prokaryotes maintain a relatively stable existence, facing little competition due to their modest requirements, which also diminishes their ability for evolution. The emergence of the original eukaryotic cell is hypothesized to have resulted from a fusion event between two prokaryotes, when an eubacterium infiltrated an archaebacterium, which then evolved into an organelle within the archaebacterium. This event is considered rare, since prokaryotes lack a capacity for endocytosis (movements across the cell wall).

This fusion activated the evolutionary potential of certain prokaryotes, propelling them to evolve into more complex eukaryotic organisms.[3] **The enriched function of a eukaryotic cell is thus traced back to the original gene of prokaryotes, which is what we mean by the 'evolutionary potential' of prokaryotes**. For example, introns, pieces of genes that gave rise to proteins with diverse functions, originally existed in prokaryotes as self-splicing redundancies. These introns gained significance when symbiotic events occurred. Similarly, proteins functioning in the cytoskeleton of eukaryotes can be traced back to the core filament-forming proteins in prokaryotes. **All that a eukaryotic cell did was to elaborate the function through gene duplication and specialization**.[4]

As eukaryotic cells' qualities evolved and endocytosis developed, their survival became increasingly challenging due to the potential threat of being engulfed by others. This initiated a competition of scaling, as larger cells had

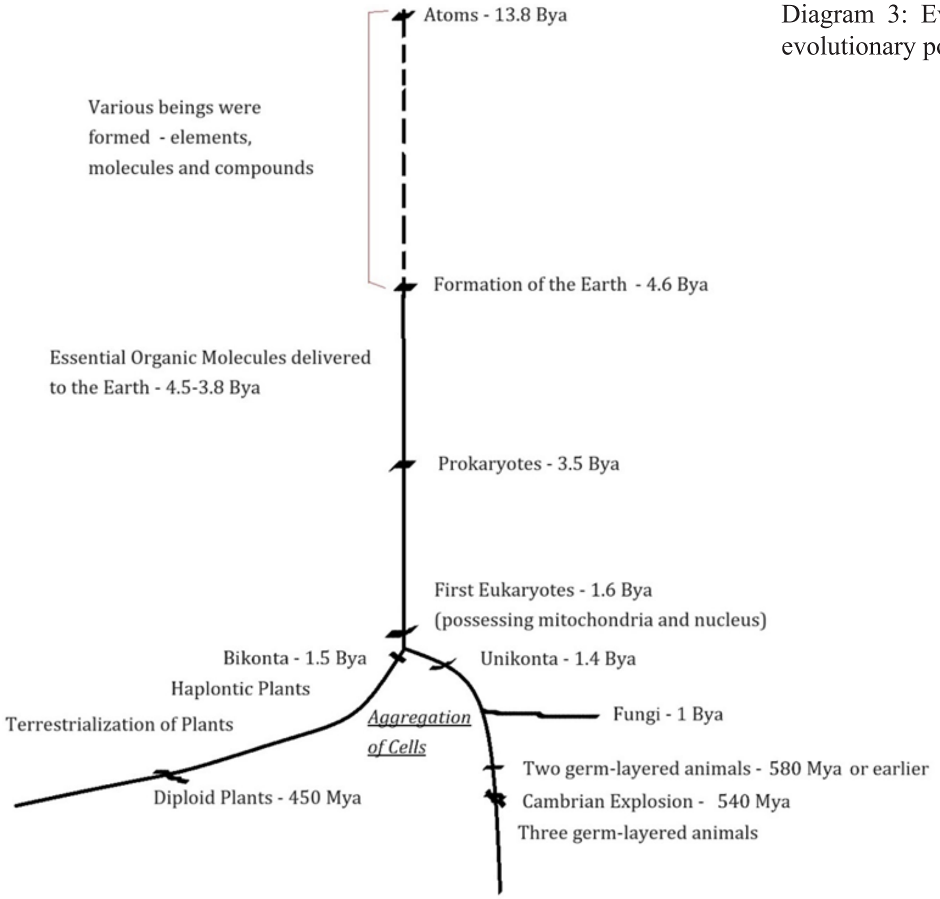


Diagram 3: Evolutionary schema of typical beings having evolutionary potential. Diagram by Ye Chen.

a better chance to avoid engulfment. But simply enlarging the size of a single cell was not a straightforward solution, due to physical constraints – such as the problem of surface-volume ratio.[5] The most efficient survival strategy was cell aggregation. Various attempts were made in this regard – individual cells formed into filaments, clusters, balls or sheets, such as algae a billion years ago and sponges 800–750 million years ago.[6]

However, it wasn't until 600–700 million years ago that a significant surge in atmospheric and oceanic oxygen levels triggered major metazoan diversification. These environmental conditions set up an optimal backdrop for eukaryotic cells to display their diverse evolutionary potential as more interactable-qualities allowed the evolutionary potential of certain eukaryotic cells to be activated and turn into interactive-qualities.

Such evolutionary potential included eukaryotic cells' innate capacity for aggregation, adhesion and cloning, along with dynamic cytoskeletal and membrane systems, and specialized molecular-signalling networks for cell communication. This enabled flexible development routes of multicellularity by realizing different patterns of gene regulation and gave rise to a variety of germ-layered animals.[7]

The transition to multicellularity led to a heightened demand for resources, which intensified external competition and internal aspects of physiological development. The evolution of a digestive system reflected the increased demand for energy and nutrient acquisition.[8] Interestingly, among the eukaryotic cells, some special groups, like fungi, did not engage in this trend and diverged from other eukaryotic cells 1 billion years ago. (Diagram 3).

Fungi chose a different pathway, foregoing the more efficient resource acquisition methods of animals. They developed no circulatory, skeletal or digestive systems but instead retained extra-cellular digestion (a prokaryotic strategy) by absorbing decayed organic materials.[9] Fungi are a typical example of eukaryotic cells that lack an evolutionary potential, which prevented them from developing into a higher level.

Ultimate Cause of Evolution

Firstly: It is evident that **the evolutionary process of all entities starts from *inherent-instability***. This signifies the inability of an entity to maintain its existing state of being or identity. It applies to all entities in the universe. An atom can evolve into a molecule when encountering certain external factors, such as other atoms, while prokaryotic cells, though existing in a stable state for a billion years, still evolved into eukaryotic cells when exposed to other external conditions. It is essential to recognize that all entities, regardless of whether they ultimately do evolve, inherently possess a degree of instability. **Under the right conditions, they can always transition from their existing state and lose their identity**.

Secondly: **All entities possess an *innate inclination towards achieving stability*, in other words, to avoid potential instability**. This desire for stability can also be referred to as the *desire for continued existence*. This does not necessitate the presence of specific sensorimotor systems; but it is manifested through conservation and variation forces that operate within all entities.[10] When confronted with external factors that challenge their stability, the desire for stability is reflected through the variation force, as when we observe the tendency of particle interaction to form molecules or compounds, and living beings' efforts towards adaptation.

Thirdly: While all entities exhibit inherent-instability and an inclination for stability, **evolution can only take place when an entity possesses the *potential quality to evolve* (evolutionary potential)**. Evolutionary potential appears at different stages along the evolutionary route. Portfolios of all possible qualities are created and accumulate within entities, which are endowed with none, little or strong evolutionary potential.

However, the activation of this potential is subject to intricate passive and active factors. Passive factors have a likelihood of all requisite conditions aligning simultaneously, while active factors involve survival pressures, such as heightened external competition or increased demands for nutrients and energy to maintain their internal dynamics. These active factors spur the selection of a more favourable portfolio of qualities for entities. **Active factors appeared at the stage of living-beings when conditions increased, adding more opportunities for them to develop their evolutionary potential**.

When an entity evolves to a higher level of organization (as a new entity), it means that that its latent evolutionary potential develops into the new entity's interactive-quality. Initially, this evolutionary potential may appear insignificant within the framework of the original entity, akin to seeds awaiting their germination, but it gains significance as it grows into the new being's interactive-quality.[11]

Fourthly: We need to examine the relationship between inherent-instability, the desire to achieve stability, and the potential quality to evolve (evolutionary potential). When an entity at a state of instability, inclines to achieve a new stability – through active or passive means in response to various factors – it departs from its original state of stability and attains a new and higher level of stability. At this point, the entity's evolutionary potential comes into play, serving to compensate the loss of its initial stability and reach a new level of stability. This relationship can be represented in a formula:

> (Original Stability) – (Loss of Stability due to specific triggers) + (Development of Evolutionary Potential) → New Level of Stability.

As discussed in Article 1, our concept of existence pertains to beings in an 'adaptation state,' excluding those entities that emerge and disappear rapidly as part of nature's random experiments. The elimination of these momentary entities aligns with the principles of natural selection. Nature favours those entities capable of maintaining a stable existence while eliminating those less capable. This natural process accounts for the remarkable intricacy and congruity observed in various organisms, almost as if they were tailored for specific environments or purposes. This is because entities failing to meet the requirements of an existence state have been naturally deselected.

Article 2 described how beings in adaptation states share an equivalence, as they all indicate structural-coupling of a being's interactive-qualities with its interactable-qualities or conditions. There is no inferiority or superiority in this structural-coupling; it either occurs or does not. With these foundational principles in mind, we can equate 'Original Stability' with 'New Level of Stability.' This can be interpreted as: **A being taps its evolutionary potential to compensate for the loss of stability**.

(Original Stability) – (Loss of Stability due to specific triggers) + (Development of Evolutionary Potential) = New Level of Stability.

Original Stability = New level of Stability.

Loss of Stability due to specific triggers = Development of Evolutionary Potential.

For most entities having limited potential qualities to evolve to a higher level of organization, they adopt natural drifts, adjusting their qualities to adapt to the new conditions. Correspondingly, the formula becomes:

(Original Stability) – (Loss of Stability due to specific triggers) + (Natural Drift Adjustment) = New level of Stability.

So, an entity adjusts its functions to compensate for its loss of stability. It thus becomes clear that for beings with little or no capacity to evolve or to adopt natural drifts, they are unable to reach a new level of stability and will ultimately go extinct and / or disintegrate.

Regardless of whether compensation is achieved through evolutionary potential or natural drift adjustments, it does not eliminate an entity's inherent-instability. This instability often increases as beings reach higher levels of organization, given the greater number of conditions on which they depend. Compensation only provides a temporary solution for loss of stability; it does not alter their inherent-instability. Beings at different levels of organization possess their respective degrees of instability, determined by the portfolio of conditions on which they depend. **Therefore, beyond the formula, there is a hidden parameter that signifies a being's inherent-stability.**

When certain eukaryotic cells experience a disruption in their balanced existence state, their evolutionary potential is triggered, enabling them to evolve into multi-cellularity and achieve a new balanced existence state. This doesn't imply that multi-cellularity solves their inherent-instability. At the level of multi-cellularity, cells are more specialized, and their division of labour more distinct, governed by a more intricate genetic regulatory program.

These new specialized functions then impose greater demands on internal coordination and reliance on external conditions, resulting in lower inherent-stability for multi-cellular species compared to eukaryotic cells. The evolutionary potential of multi-cellularity can be more easily activated due to heightened survival pressure and increased risks, giving rise to higher-order entities.

So, we identify two lines – a concealed line characterizing inherent-stability and a solid line illustrating temporary equivalent stability. The gap between equivalent stability and inherent-stability epitomizes the compensation initiated by entities adjusting for their loss of stability. **This compensation allows entities to temporarily restore their stability while concurrently diminishing their inherent-stability** (Diagram 4).

The fundamental nature of all entities is rooted in their inherent-instability, and their pursuit of stability (stable existence) is the ultimate cause of evolution. This pursuit of stability is manifested by an entity's compensation for its instability, whenever it is disrupted. But its ability to compensate and the strategies it employs depend on the entity's evolutionary potential, which, according to a being's vertical inter-relation, is shaped by the superposition of specific historical stages derived from nature's random experiment.

This concept is a modification of Wang's weakening-compensation model, in which entities are seen as naturally losing their inherent-stability. In this modified version, however, inherent-stability does not naturally decrease**. Its decline is contingent upon whether an entity possesses the potential to evolve to a higher level of organization and whether the necessary conditions exist to activate this potential**. In other words, not all entities experience a loss of inherent-stability.

Entities lacking evolutionary potential remain at their level of organization, subject to natural drift, until they can no longer adapt or lose the conditions on which they rely, resulting in eventual disintegration. The difference between Wang's model and my framework is in the prediction of disintegration. In Wang's system, entities disintegrate due to an inability to compensate or because inherent-stabilities decrease to near zero. In my modification, disintegration only arises from an inability to compensate.

Evolution and the Second Law of Thermodynamics

Some people may believe that the evolutionary tendency from simplicity to complexity suggests that to be stronger is the objective as well as the ultimate cause of evolution. This aligns with Erwin Schrödinger's negative entropy in

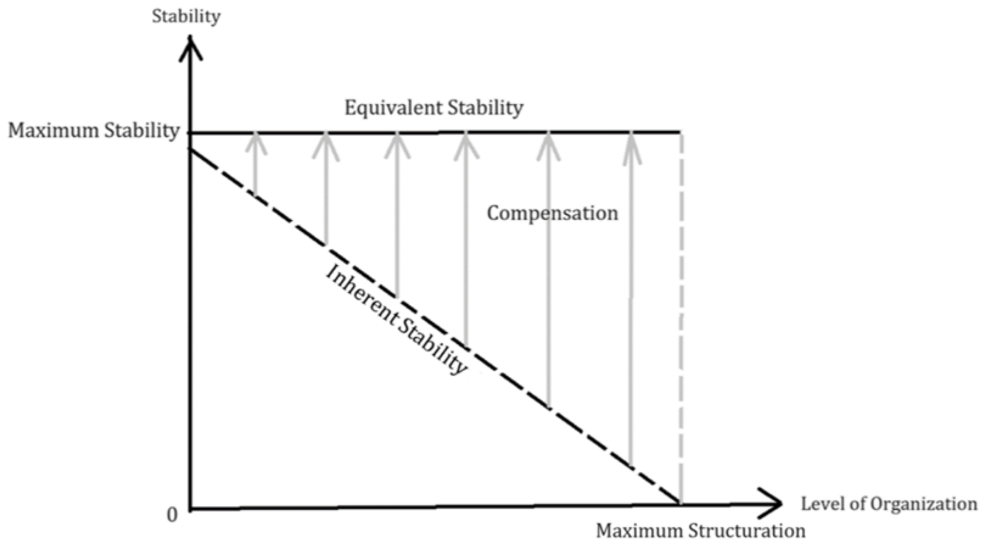


Diagram 4: Model of Existence. The X-axis measures a beings' level of organization, from 0 (simplest) to maximum structuration. The Y-axis shows the degree of stability, from 0 to the highest. Maximum stability refers to an eternally stable state that cannot be perturbated, so it cannot be reached by the inherent-stability of any entity. The progressive level of organization is measured by inherent-stability and compensation. Diagram by Ye Chen.

the system of the living organism, as he argued:

> …Living Matter, while not eluding the 'law of physics' as established up to date, is likely to involve 'other laws of physics' hitherto unknown, which, however, once they have been revealed, will form just as integral a part of this science as the former.[12]
>
> An organism's astonishing gift of concentrating a 'stream of order' on itself and thus escaping the decay into atomic chaos – of 'drinking orderliness' from a suitable environment – seems to be connected with the presence of the 'aperiodic solids', the chromosome molecules, which doubtless represent the highest degree of well-ordered atomic association we know of – much higher than the ordinary periodic crystal – in virtue of the individual role every atom and every radical is playing here.[13]

Entropy (S) is a measurable physical property associated with the degree of disorder or randomness within a system. The concept of entropy is based on the second law of thermodynamics, which posits that '… for any transformation occurring in an isolated system, the entropy of the final state can never be less than that of the initial state.'[14] This means that entropy invariably increases in an isolated system, a principle that appears at odds with Schrödinger's notion of negative entropy in living organisms, often referred to as the *Schrödinger paradox*.[15]

Schrödinger resolved this contradiction by positing that life distinguishes itself from other entities in its capacity to function as an open system that can exchange heat and matter with its surroundings. Consequently, the evolution of living organisms can counteract the natural trend outlined in the second law of thermodynamics (Diagram 5).

However, acknowledgment that the principles governing open systems do not align with principles applicable to closed systems (second law of thermodynamics) does not address the relationship between evolution and the second law of thermodynamics. Instead, it only highlights the clear differentiation between non-living and living entities, each adhering to distinct sets of physical laws.

In respect to Schrödinger's perspective, only the 'subject' is the mere concentration, whether it is a closed system of particles or an open system of organisms. But now we need to shift the approach to **macro-evolution – a system that involves both the subject – identity / existence of an entity, and the object – conditions on which the entity relies**.

Consider a primitive entity in macro-evolution – fundamental particles: They possess highly inherent-stability and disintegrate under only very limited conditions.[16] **The *principle of energy dispersal* does not mean they actually disintegrate, but that their uncooperative characteristics lead to no structure**. This aligns with our model of existence – in a closed system, individual particles can maintain their existence without

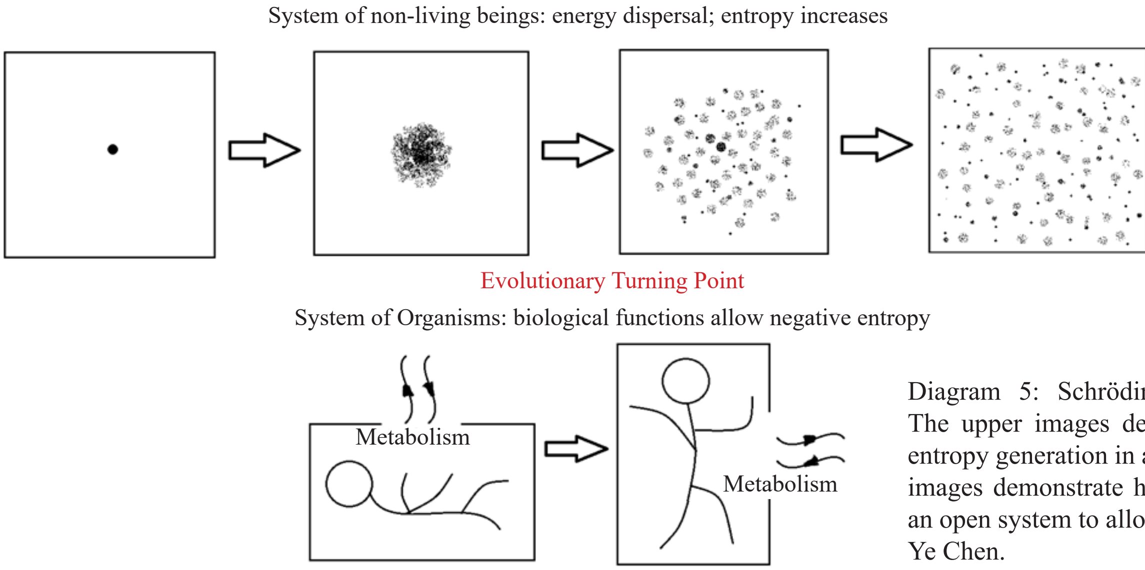


Diagram 5: Schrödinger's Negative Entropy. The upper images depict energy dispersal and entropy generation in a closed system. The lower images demonstrate how organisms function as an open system to allow negentropy. Diagram by Ye Chen.

relying on other particles, as reflected by 'energy dispersal.' It also implies that these particles have no evolutionary potential or that the conditions to activate their potential have not appeared. This is much like the lack of a societal structure among prokaryotic cells in early times.

If all particles lacked evolutionary potential and exhibited uncooperative characteristics, then they would all cease to develop and the universe would be perfectly in balance, staying constant at thermodynamic equilibrium. But this is not the case – no entity possesses absolute inherent-stability. Under specific conditions, the stability of particles can be disrupted, and their evolutionary potential can be activated, leading to the formation of more complex structures. This departure from equilibrium is often referred to as being 'far from equilibrium' in the realm of thermodynamics.

According to systems-theorist Ilya Prigogine, a system that moves out of equilibrium tends to transition into a state characterized by increasing randomness and begins to exhibit exceptional sensitivity to external fluctuations. This sensitivity can give rise to the emergence of novel patterns, representing 'a new coherence,' in which autonomous cooperation among entities develops an 'adaptive organization' fit to the environment. This is what Prigogine termed a 'dissipative structure' and suggests that evolution originated from instability – symmetry-breaking, a notion that Prigogine expressed as 'nonequilibrium being a source of order.'[17]

Compared to the chaotic behaviour of particles in thermodynamic equilibrium, the more complicated state of non-equilibrium reveals coordination between its components and the overall endeavour (compensation) to combat external fluctuation.[18] **The chaotic particles and orderly-organized entity share one thing in common – the maintenance of their identity – as simple particles or a complex organization**. Their orderly or chaotic manner reflects different existence states as well as different degrees of inherent-stability (different identities at different stages of evolution).

The second law of thermodynamics applies to all entities. Entities with a high inherent-stability manifest independence, so they appear as chaos. In contrast, complex entities with a low degree of inherent-stability must maintain stability by relying on other entities, for example, ensuring the coordination of internal networks and exchange of energy with the environment. Failure to do so results in their transition towards a state of disorder leading to disintegration. Structures with optimal capacity to maintain their identity are favoured by nature.

The second law of thermodynamics compels entities to evolve from passive existence states to more active ones. Compared to their ancestral entities, newly derived entities rely on more conditions and so must adopt increasingly proactive approaches, transforming disorder into order. Such initiatives are discerned in the 'cooperative behaviour' of some non-living entities. In a hypothetical world characterized by negentropy (reverse entropy), these entities would not develop such initiatives, since nature would have already put them in a state of order.

The Primal Singularity Hypothesis

If inherent-instability constitutes an ultimate cause of evolution, we must ask – from where did it come? In other words, what causes the symmetry-break that led to a thermodynamic state far from equilibrium? This gave rise to a primal singularity hypothesis.

(You may first review the principles I provided above on the Ultimate Cause of Evolution before moving on to the following hypothesis.)

The seed of inherent-instability lies in the Primal Singularity, where differentiation and evolution did not yet begin. As the simplest, undifferentiated entity, it relied on the least conditions to exist, hence it lies at the maximum inherent-stability (the leftmost point in Diagram 4). It cannot possess absolute, eternal stability, otherwise it would be non-reactive, and the Big Bang wouldn't have occurred. Thus, maximum inherent-stability is not equal to maximum stability, but instead is slightly below maximum stability, which means its symmetry can still be broken on certain conditions. This gap between maximum stability and inherent-stability can be viewed as a permanent and minimum loss in stability existing in the Primal Singularity, as well as all its derived entities. In other words, inherent-instability existed at the beginning of the universe – the common ancestor of all entities.

This symmetry-breaking moment signifies the first time in the universe that an entity (primal singularity) loses stability. It is this loss of stability that triggers the singularity's potential to evolve into specialized entities with specialized forces, striving to combine them to reach a new level of stability. However, the evolved entity's inherent-instability becomes even less than its initial state, and, as it continues to evolve, it can only lose more (Diagram 4). Thus, the primal singularity has a permanent and minimum loss of stability, since its derived and differentiated roles only temporarily resolve the loss to reach a new level of stability, while increasing its demand for conditions in the maintenance of its existence.

Conclusion

According to our theory, evolution is driven by two factors – entities' inherent-instability and the desire to achieve stability. An entity achieves stability through its unique way of making structural changes, by which it is able to compensate for the loss in stability. However, inherent-instability is the nature of all entities and cannot be fixed; only instability can be temporarily addressed through effective compensation.

Structural changes take place through two approaches – natural drift or evolution. The former refers to variations without upgrading the structure, while the latter's structure rises to a higher level with enriched functions. Only entities with evolutionary potential can evolve into a more complex identity and, when they succeed, their inherent-instability increases, since their higher-level of structure relies on more conditions, both internally and externally. Please note that evolutionary potential is not an absolute but a relative concept – it is never something existing intrinsically at the start but appears at some point in its history, as we can only infer later when it gets activated.

Preview of Article 4

In this paper, we have introduced the foundational model of existence. In our upcoming article, we will delve into a range of topics that are subjects of extensive debate within the field of philosophy. These topics include consciousness, time and space, the law of causation, logic, and the profound implications of the model of existence. These discussions will be informed by the principles we have derived from the first three articles, as well as insights from the fields of animal diversity and molecular biology.

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Endnotes

1 Zhu 2019. Jacquot and others 2014. Rodnina and others 2006. Gunner and others 2013. Fillingame 1997.

2 Traverse 2007: 71.

3 Emelyanov 2003.

4 Koonin 2006. Wickstead and Gull 2011.

5 As cells increase in size, they encounter the challenge of maintaining an appropriate surface-to-volume ratio. This is because the surface area (measured in square units) increases at a slower rate compared to the volume (measured in cubic units). Consequently, the surface area available for exchange with the external environment (nutrients in and waste out) doesn't keep pace with the metabolic needs of the growing cell.

6 Knoll 2011.

7 Grosberg and Strathmann 2007. Knoll 2011. Kirk 2005.

8 Primitive organisms, such as *Trichoplax adhaerens*, employ a straightforward method of intracellular digestion known as phagocytosis. In this process, the cell membrane surrounds and engulfs food particles to create food vacuoles, followed by the release of enzymes for intracellular digestion. Moving up to coelenterates, a single opening for both ingestion and waste elimination was developed, marking the introduction of an alimentary canal which allows for partial extracellular digestion. However, the digestive system's incompleteness at this stage restricts complete extracellular digestion within the organism's body. It is only with the evolution of more complex animals, such as mammals, that we witness the development of specialized organs dedicated to extracellular digestion. These specialized organs enable the sorting and processing of food in a manner that allows for efficient extracellular digestion.

9 Steenkamp and others 2006.

10 In Article 2, I addressed how the conservation force exists in all beings. Although we do not see a strong 'willingness' to be conserved in non-living beings, as we do in living beings, the immense proportions and age of non-living beings in the universe imply a more robust and powerful natural conservation force operating on them.

11 For example, wisdom of the ancient Greek philosophers did not play an important role in enhancing the social functions of ancient Greece. During that era, fields such as philosophy and mathematics were more like logical games engaged in by erudite minds. Yet, it was this very wisdom that served as the 'seed' responsible for the Renaissance and Enlightenment periods, which subsequently catalyzed the augmentation of societal functions, particularly during the Industrial Revolution. In this perspective, the wisdom of Greek philosophers can be regarded as the evolutionary potential that ultimately evolved into the distinctive 'interactive quality' of the new society.

12 Schrodinger 1944: 68.

13 Schrodinger 1944: 77.

14 Fermi 1936:77.

15 Schneider and Sagan 2005: 15.

16 In Article 2, I compared the energy required to bind bottom quarks, protons with neutrons, electrons with nuclei, and atoms with atoms. We observed that as particles exhibit increased structural complexity, they display a greater susceptibility to disintegration, accompanied by a significant reduction in the energy necessary for their dissociation.

17 Prigogine and Stengers 1984: 13, 84, 124, 129, 165, 187.

18 Prigogine and Stengers 1984: 189.

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Evolution = Exchange

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Abstract: Darwin's theory of natural selection raises two critical questions: What is ultimately being selected? Why is it inevitably being innovative? In response, the five key theories of evolution begin with species, genes, organisms, systems, processes. And they lead to a sixth key theory that begins with exchange. Specifically, I re-configure Darwin-Peirce-Einstein's special theories of evolution-semiosis-relativity in a radical theory of exchange←→signification←→value. In this context I suggest that the relative signifying relations of exchange are both exuberantly innovative and restrictively selective and they drive the process of evolution. Instead of beginning with a *post hoc* theory of restrictive selection, therefore, I begin with an *ad hoc* theory of exuberant innovation. Every so-called thing in this so-called universe is actually no-thing more and no-thing less than a co-incidental articulation of the long evolutionary history of the relative signifying relations of exchange—beginning with energy←→mass ←→ mass←→energy. In fact, time itself can be understood as the rhythmic syntax of exchange. While some recent general theories of evolutionary history begin with energy flows, quantum bits, emergent complexities, etc., I suggest that the dynamic of exchange evolves nature, the practice of exchange evolves culture, the syntax of exchange evolves history. Here we arrive at the proof that is to be demonstrated: Evolution = Exchange.

Keywords: Evolution, Exchange, Innovation, Selection, Relativity, Time, Semiotics, Theory, Writing, History

1. Darwin

As I was saying,* a great mystery lies at the heart of Darwin's great book. Instead of discovering the *origin* of species, he discovers the *never-ending-process* of evolution:

> As many more individuals of each species are born than can possibly survive; and, as consequently, there is a frequently recurring struggle for existence, it follows that any being, if it vary however slightly in any manner profitable to itself, under the complex and sometimes varying conditions of life, will have a better chance of surviving, and thus be *naturally selected*. From the strong principle of inheritance, any selected variety will tend to propagate its new and modified form. (1998: 6)

That is, Darwin discovers the never-ending-process of population→competition→location and variation→selection→modification—plus inheritance. In other words, Darwin discovers that the origin has no originality. And that discovery brings us deeper into the great mystery. As a result of his radical theory of evolutionary time, Darwin realizes that he can't actually define a species: "Certainly no clear line of demarcation has yet been drawn between a species and a sub-species…or again between a sub-species and well-marked varieties, or between lesser varieties and individual differences" (1998: 44). And then he states, "I look at the term species, as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety… [which] is also applied arbitrarily …" (1998: 45). In other words, Darwin discovers that the species has no specificity. And that discovery leads to further complications. Is it the undefinable species, sub-species, or variety that is ultimately being selected? Is it the undefinable identity, similarity, or difference? In other words, Darwin discovers that the selection has no selectivity. So if the origin has no originality, the species has no specificity, the selection has no selectivity, then how can Darwin write a book, *On the Origin of Species by Means of Natural Selection* (1859)?

Darwin's radical diachronic rhetoric of apparent difference explodes Linnaeus' conservative synchronic grammar of formal similarity. That is, the temporal flow of *On the Origin of Species* (1859) bursts open the spatial grid of *Systema Naturae* (1758). It bursts open the "lines

* This essay develops the argument I first outlined in, "A Theory of No-Thing" (2019), and, …*The Time Being: Allegories of Exchange* (2000). I revisit select passages from each text in order to re-orient the reader.

of demarcation." As a result, Darwin confronts the radical implications of his radical theory of evolutionary time: the origin has no originality, the species has no specificity, the selection has no selectivity. He opens his great book with the suggestion that the origin of species is "that mystery of mysteries" (1998: 3), but he actually uncovers a greater mystery. If it isn't the species *per se* that is ultimately being selected, then what is ultimately being selected? And yet instead of solving that great mystery, Darwin retreats from it. He retreats from the radical implications of his radical theory of evolutionary time.

Immediately after acknowledging that he can't distinguish a species from a sub-species and a sub-species from a variety, he thinks about returning to the Linnaean project of drawing up a new table of them: "Guided by theoretical considerations, I thought that some interesting results might be obtained in regard to the nature and relations of the species which vary most, by tabulating all the varieties in several well-worked floras" (1998: 45). And then again he hesitates: "At first this seemed a simple task, but Mr. H.C. Watson… soon convinced me that there were many difficulties, as did subsequently Dr. Hooker in even stronger terms" (1998:45). And presumably these difficulties include the problem of trying to re-impose the taxonomic grid of formal similarity on the evolutionary flow of apparent difference. They include the problem of trying to spatialize time, catalogue time, stop time. How does Darwin resolve these difficulties? He doesn't. He states, "I shall reserve for my future work the discussion of these difficulties, and the tables themselves of the proportional numbers of the varying species" (1998: 45). In other words, Darwin puts off the discussion of the radical implications of his radical theory of evolutionary time for another time.

So how can Darwin proceed? A few pages later he explains,

> We have seen that there is no infallible criterion by which to distinguish species and well-marked varieties; and in those cases where intermediate links have not been found between doubtful forms, naturalists are compelled to come to a determination by the amount of differences between them, judging by analogy whether or not the amount suffices to raise one or both to the rank of species…I have endeavored to test this numerically by averages. (1998: 48)

This is a very scientific-sounding way of saying that if he and his fellow naturalists want to continue using the Linnaean classification system, then they must guess which particular example fits into which particular category. They must fudge the diachronic details in order to squeeze a particular example into a synchronic box. In other words, Darwin develops his own version of the fuzzy logic of identity, fuzzy grammar of similarity, fuzzy rhetoric of difference. And the struggle to define the identity of a species continues to this day. As Zimmer (2024) notes, contemporary "…biologists cannot agree on what a species is. A recent survey found that practicing biologists use 16 different approaches to categorizing species" (2024: D1).

The multiple contradictions of Darwin's narrative—time/space, difference/identity, appearance/essence, etc.—are fantastically ironic. However, instead of suggesting, in the spirit of Derrida (1966), that Darwin's phenomenal rhetoric of time and structural logic of space deconstruct one another, I want to return to the radical implications of his radical theory. I want to return to the great mystery that lies at the heart of his great book: If it isn't the species *per se* that is ultimately being selected, then what is ultimately being selected? How can we talk about the *origin* of species—or, for that matter, the *origin* of anything? How can we advance Darwin's special theory of evolutionary biology? How can we write a new general theory of evolutionary history? In order to answer these questions we must first take a closer look at the different ways in which Darwin's writing strategies define his thinking strategies—and vice versa.

Peirce states that, "The science of semiotics has three branches…pure grammar, logic proper…pure rhetoric" (*CP*: 2.229). If his modern version of the medieval trivium holds true for every form of signification, then no wonder Darwin unwittingly recapitulates the classical version of it in the concluding remarks of his great book. That is, Darwin invokes what amounts to a radical neo-Socratic rhetoric of the exigency of appearance: "…we shall have to treat species in the same manner as those naturalists treat genera, who admit that genera are merely artificial combinations made for convenience. This may not be a cheering prospect; but we at least will be freed from the vain search for the undiscovered and undiscoverable essence of the term species" (1998: 392). He invokes what amounts to a moderate neo-Aristotelian grammar of the teleology of form: "And as natural selection works solely by and for the good of each being, all corporeal and mental endowments will tend to progress toward perfection" (1998: 395). And he invokes what amounts to a conservative neo-Platonic logic of the ontology of essence: "Therefore I should infer from analogy that probably all the organic beings which have ever lived on this earth have descended from some one primordial form, into which life was breathed by the Creator" (1998: 391).

In fact, throughout his narrative, Darwin unconsciously transposes the classical mimetic hierarchy of metaphysics and transforms it into the modern mimetic hierarchy of evolution. In *The Republic* (ca. 375 B.C.), Plato appropriates the style and distorts the substance of Socratic dialectics in order to legitimate his Platonic metaphysics. His Platonic-Socrates explains his mimetic hierarchy to his Platonic-Glaucon:

> We get, then, these three couches, one, that in nature, which, I take it, we would say that God produces, or who else?
>
> No one, I think.
>
> And then there was one which the carpenter made.
>
> Yes, he said.
>
> And one which the painter. Is not that so?
>
> So be it.
>
> (*Republic*, X.597b; 1996: 822)

The Platonic-Socrates argues that God creates the metaphysical essence of all couches; the carpenter constructs the physical form of a particular couch; the painter captures the dialectical appearance of that couch. So, in all cases, the heavenly idealized couch defines the earthly realized couch which defines the watery visualized couch. That's why—despite the fact that there are innumerable kinds of couches—we can recognize each different variety as a couch.

And yet how can we possibly have any knowledge of the heavenly ideals? The Platonic-Socrates argues that, before we are born, our immortal soul transmigrates through the heavenly realms. As a result, when we are born, our mortal mind retains an innate memory of the heavenly ideals (*Phaedo*, 72-76; 1996: 54-60). In this way the Platonic logic of metaphysics supposedly trumps the Aristotelian grammar of physics which supposedly trumps the Socratic rhetoric of dialectics. So, in the classical Greek mimetic hierarchy, the painter's couch merely imitates the carpenter's couch which merely imitates God's couch. And in this way Plato replaces the radical-dialectical Socratic-Socrates of the *Apology*—who re-evaluates the state-sanctioned mimetic hierarchy of value—with the conservative-metaphysical Platonic-Socrates of *The Republic*—who re-asserts the state-sanctioned mimetic hierarchy of value.

In this context we can recognize how Darwin writes—and so thinks—within the heuristic framework of classical philosophy. And we can recognize how he re-orients it. While Plato's mimetic hierarchy connects sky→earth→water, essence→form→appearance, logic→grammar→rhetoric, Darwin's mimetic hierarchy connects depth→median→surface, identity→similarity→difference, logic→grammar→rhetoric. Plato begins with heavenly essential ideals, Darwin begins with earthly identical species. And, in fact, recent genetic research does suggest that all living animals did evolve from a common ancestor that existed about 650 million years ago. Similarly, it suggests that all life on earth did evolve from a common ancestor that existed about 4 billion years ago. In a remarkable feat of paleo-genetic synthesis, Paps and Holland (2018) infer the identity of 6,331 genes belonging to the first animal (cf. Zimmer, 2018: D3). Similarly, in another remarkable feat of paleo-genetic synthesis, Weiss, Martin and their colleagues (2016; 2018) infer the identity of 355 genes belonging to LUCA, the Last Universal Common Ancestor, a single-celled bacterium-like microorganism (cf. Wade, 2016: D1). However, it requires a great ladder of metaphysics, a great chain of being, or a great leap of faith to get from these primeval genomes to what Darwin calls the breath of the Creator. And it requires some kind of biological ontology to define the essential identity of a species. No wonder, then, that Darwin quickly discovers that he can't actually define a species.

So we return to the great mystery that lies at the heart of Darwin's great book: What is ultimately being selected? And that great mystery is wrapped in a great enigma: Why is it inevitably being innovative? Darwin notes that, "The result of the various, quite unknown, or dimly seen laws of variation is infinitely complex and diversified" (1998: 12). He confesses that, "Our ignorance of the laws of variation is profound" (1998: 137). And again, "We are profoundly ignorant of the causes producing slight and unimportant variations…" (1998: 161). Darwin prefers to plead ignorance of the causes of innovation if the only alternative is to preach certainty of the principles of creationism. Similarly, he argues for natural selection and against intelligent design. He suggests that slight variations—no matter how they're generated—when naturally selected down the ages can even explain the evolution of complex forms like the eye (1998: 154).

However, Müller (2003) reminds us that natural "… selection has no innovative capacity: it eliminates or maintains what exists. The generative and ordering aspects of morphological evolution are thus absent from evolutionary theory" (2003: 51). In other words, "natural selection" is a *post hoc* name Darwin assigns to Malthusian populations and Hobbesian competitions in Lyellian locations. Then again, he recognizes that the "recurring struggle for existence" is only one example of the varied "mutual relations of all the beings" (1998: 6)—and he also recognizes that natural selection is supplemented by sexual selection (1998: 73). Furthermore, despite his anthropomorphic analogy between artificial selection and natural selection in the first two chapters of his great book, he argues that natural selection has no agency or intention. That is, Darwin's 1859 metaphor of "natural selection" (1998: 6) isn't the biological equivalent of Smith's 1776 metaphor of the "invisible hand" (1976: 477).

In short, Darwin's theory of population→competition →location and variation→selection→modification—plus inheritance—explains in broad terms *how* evolutionary biology works, but it doesn't explain in specific terms *what* is ultimately being selected or *why* it is inevitably being innovative. It explains in broad terms the evolutionary adaptations of life on earth—including portmanteau animals like kangaroos, platypuses, giraffes—but it doesn't explain in specific terms the exuberant innovations of life on earth. Why kangaroos? Why platypuses? Why giraffes? And, for that matter, Why life? Since Darwin doesn't know exactly what nature selects or exactly why nature innovates, then his theory of natural selection puts the cart before the horse. That is, Darwin's retrospective theory privileges utilitarian selection over exuberant innovation. As a result, he re-domesticates evolutionary time. In this way Darwin's argument returns us to the critical questions of selection and innovation, evolution and theory, thinking and writing. And so do the arguments of his successors.

2. Successors

Mendel (1865) and his heirs attempt to resolve the multiple contradictions of Darwin's argument and thus solve the great mystery wrapped in the great enigma in Darwin's great book. They suggest that it isn't the species *per se* that is ultimately being selected and that is inevitably being innovative, rather it's the gene. Klein, for example, opens *The Human Career* (2009)—his comprehensive textbook survey of recent advances in evolutionary anthropology—with the confident assertion that, "The species is the least arbitrary and the most fundamental evolutionary unit, and it must be understood before any consideration of evolution, even one focused tightly on a single species like *Homo sapiens*" (2009:1). Why is Darwin so nervous about defining a species and why is Klein so confident about it? Precisely because Darwin knows nothing about genetics and Klein knows a lot about it. He continues: "…no matter how detailed the resemblances between two groups of organisms, if individuals cannot exchange genes between groups, the two populations must be assigned to different species" (2009: 1; cf. Arnold, 2007, 2015; Kulmuni *et al.*, 2020). In short, a species can be defined as geographically associated groups of organisms that successfully exchange genes. And most evolutionary biologists would acknowledge the pragmatic efficacy of that working definition—even if it remains problematic for the precise taxonomic categorization of many microorganisms as well as for the precise taxonomic distinctions between and among differences, varieties, sub-species and species.

So instead of focusing on the origin of species *per se*, some 20th century evolutionary biologists develop the "Modern Synthesis" (Huxley, 1942)—combining and advancing Darwin's theory of natural selection and Mendel's theory of genetic inheritance. Specifically, they study—and their successors continue to study—mechanist-cybernetic genetics, molecular-chemical genetics, population-statistical genetics and many related topics. In this way they shift the focus of analysis from the mimetic hierarchy of evolutionary biology to the mimetic hierarchy of evolutionary genetics: i.e. from the deep logic of species→median grammar of varieties→surface rhetoric of differences to the deep logic of genes→median grammar of genotypes→surface rhetoric of phenotypes. In short, they shift the focus from species to genes. Here we return to the critical questions of selection and innovation, evolution and theory, thinking and writing.

And so we must ask: What, exactly, is a gene? Population-statistical correlations and molecular-chemical helixes only begin to answer that question. In turn, Hamilton opens his classic mechanist-cybernetic sociobiological essay, "The evolution of altruistic behavior" (1963), with the metaphor of the altruistic gene: "As a simple but admittedly crude model we may imagine a pair of genes g and G such that G tends to cause some kind of altruistic behavior while g is null" (1963: 354). Then, in the very next paragraph, Hamilton's "crude" genetic metaphor becomes a sophisticated genetic metaphysics: "Thus a gene causing altruistic behavior towards brothers and sisters will be selected only if the behavior and the circumstances are generally such that the gain is more than twice the loss…" (1963: 355; cf. 1964). Since siblings share certain percentages of certain copies of certain genes, then the enhanced fitness of the beneficiary-recipient-sibling leads to the enhanced fitness of the recipient's copy of the donor's altruistic gene. So the theory of kin selection—which is, ultimately, a theory of genetic selection—explains how multiple copies of the altruistic gene can propagate throughout a population despite the reduced fitness of the altruistic-donors. However, we can't forget how quickly Hamilton's "crude" *metaphor* of a gene that "we may imagine… tends to cause" altruistic behavior becomes Hamilton's sophisticated *metaphysics* of "a gene causing altruistic behavior." Plato begins with heavenly essential ideals, Darwin begins with earthly identical species and Hamilton begins with chthonic structural genes. In effect, Hamilton suggests that structural genes program functional genotypes which generate phenomenal phenotypes. As a result, he and his fellow sociobiologists complete the modern scientific transposition, transformation and *inversion* of Plato's ancient mythic mimetic hierarchy. The metaphysical descent, sky-essence→earth-form→water-appearance, becomes the physical ascent, deep-gene→median-genotype→surface-phenotype. In this way metaphysics becomes physics—and physics becomes metaphysics.

In turn, Trivers (1971) takes up Hamilton's *inverted* genetic metaphor and metaphysics and suggests that reciprocal altruism enhances the fitness of both participants—even when practiced across species. So, for example, when a wrasse scours a grouper, the wrasse gets a good meal and the grouper gets a good cleaning. As a result, they each have a greater chance of passing down copies of the theoretical "gene" that structurally "causes" reciprocal altruism. In turn again, we can't forget how quickly Hamilton and Trivers' inverted *metaphor* and *metaphysics* of the altruistic gene becomes Wilson's inverted *metanarrative* of the altruistic gene. Wilson (1975) states that "…the central theoretical problem of sociobiology [is] how can altruism, which by definition reduces personal fitness, possibly evolve by natural selection" (2000: 3). He offers Hamilton's solution: i.e. kin selection which is, ultimately, genetic selection, which is, ultimately, genetic metaphysics.

In effect, Hamilton, Trivers and Wilson are working out the sociobiological mimetic hierarchy and economy of genetic exchange. And they are basing that mimetic hierarchy and economy on the structural causality of the altruistic gene. According to Plato the heavenly essence of altruism defines the earthly form of altruism which defines the watery appearance of altruism. According to Hamilton, Trivers and Wilson the structural gene of altruism defines the functional genotype of altruism which defines the phenomenal phenotype of altruism. Again, the modern sociobiologists invert the classical mimetic hierarchy and, as a result, their new physics becomes their new metaphysics. However, it goes without saying that the science of genetics has led to great advances in the understanding of everything from the color of eyes to the cause of disease. It goes without saying that brilliant work has been done and is being done in understanding the mediated relations of genetic codes and biological organisms. And it goes without saying that the discoveries made by the 19th, 20th and 21st century genetic researchers rank among the greatest achievements of modern science. It is critically important, therefore, that we recognize how the science of genetics has been and is being written up—how it is being narrated, for example, by the enormously influential school of sociobiology.

Since every scientist who writes up a scientific theory inevitably employs whole sets of metaphors-metaphysics-metanarratives, then every scientist must ask a series of questions: How do the classical mimetic hierarchies and mimetic economies of Plato's heavenly-essence→ Aristotle's earthly-form→Socrates' watery-appearance evolve the inverted modern mimetic hierarchies and mimetic economies of modern science? In turn, how do the inverted modern mimetic *hierarchies* of analysis (e.g. chthonic-structure → earthly-function → watery-phenomenon); the inverted modern mimetic *registers* of analysis (e.g. mechanist-cybernetics→molecular-chemistry→population-statistics); and the inverted modern mimetic *levels* of analysis (e.g. deep-logic→median-grammar→surface-rhetoric) evolve the modern mimetic *theories* of nature and how do these modern mimetic *theories* evolve them? How do the inverted modern mimetic hierarchies-registers-levels represent different time-scales? How do they define and re-define the modern mimetic economies of nature? In short, how does the evolutionary history of scientific writing generate the heuristic strategies of scientific thinking—and vice versa?

Wilson (1975), for example, argues that, "…the organism is only DNA's way of making more DNA. More to the point, the hypothalamus and the limbic system are engineered to perpetuate DNA" (2000: 3). He suggests that genes engineer biological systems that manufacture genes. And, suddenly, a genetic *metaphor* becomes a genetic *metaphysics* which becomes a genetic *metanarrative*. It isn't the high-heavenly-essences that define the median-earthly-forms that define the surface-watery-appearances, rather it's the deep-structural-genes that define the median-functional-genotypes that define the surface-phenomenal-phenotypes. In this context Wilson occasionally supplements his primary mechanist metaphors with secondary cybernetic metaphors. He suggests, for example, that, "The hypothalamic-limbic system…has been programmed…" in a way that "orchestrates behavioral responses" for the proliferation of genes (2000: 4). He concludes his mechanist-cybernetic metaphysical-metanarrative with the suggestion that the role of sociobiology in the future will be to "reconstruct the history of the machinery" and to "monitor the genetic basis of social behavior" (2000: 575).

In turn, Dawkins (1976) doubles down on Wilson's mechanist-cybernetic metaphysical-metanarrative: "We are survival machines—robot vehicles blindly programmed to preserve the selfish molecules known as genes" (2006: *xxi*). The genes are the cybernetic software, the brain is the cybernetic hardware and the body is the robot vehicle that obeys their commands. In other words, the mimetic distance between the deep structure of genes and the surface phenomenon of phenotypes is so vast that in order to bridge that mimetic distance Dawkins suggests we need a mechanist-cybernetic metaphysical-metanarrative of selfish genes that code for the propagation of selfish genes and robot bodies that automatically obey that code. In this way the mimetic hierarchy of classical philosophy is, once again, transposed, transformed and inverted in modern sociobiology. While the mythical metanarrative of classical philosophy bridges the vast mimetic distance between heavenly metaphysics and watery dialectics, the scientific metanarrative of modern sociobiology bridges the vast mimetic distance between deep structures and surface phenomena.

Then again, we must ask: How does altruistic behavior become "…the central theoretical problem of sociobiology"? Kropotkin (1902) reads Darwin (1859; 1871) through the looking glass of his explicit anarchist economics of communal-interest and shared abundant wealth. So he argues that, for Darwin, "mutual aid" actually plays a larger role in the story of evolution than "mutual struggle." In contrast, Hamilton (1963; 1964) and his heirs read Darwin (1859; 1871) through the looking glass of their implicit neoclassical economics of self-interest and hoarded scarce wealth. So they argue that, for sociobiology, "altruistic behavior" actually becomes "the central theoretical problem" of evolutionary theory. And, in order to solve that problem, Hamilton (1963; 1964) and his heirs reverse Smith's (1776) argument. While Smith suggests that the deist logic of the capitalist market transforms the cost of self-interest into the benefit of communal-interest, Hamilton and his heirs suggest that the cybernetic logic of the genetic market transforms the cost of altruism into the benefit of selfishness. Again, the altruistic gene selfishly reproduces copies of itself when the altruistic-donor-sibling aids the beneficiary-recipient-sibling. And, again, that's because the beneficiary-recipient-sibling carries copies of the same altruistic gene as the altruistic-donor-sibling. In short, the different looking glasses of anarchist, socialist, Marxist and classical, neoclassical, libertarian economics frame the different modern scientific analyses of natural-cultural-historical exchange in different ways.

So if, for example, we credit the exchange relations of what Hrdy calls, *Mothers and Others* (2009)—that is, if we credit the enormous investment of nurturing the young, not to mention caring for the elderly, as a critical part of the fundamental economics of evolutionary biology instead of as an extraordinary act of evolutionary altruism—then we can agree with Kropotkin that mutual aid, or altruistic behavior, isn't a critical problem for Darwin's theory. It's only a critical problem for the conservative, patriarchal, neoclassical versions of Smith's theory of enlightened economics (e.g. Becker, 1993; Friedman, 1962; Hayek, 1944) as applied to Darwin's theory of evolutionary biology (e.g. Dawkins, 1976; Hamilton, 1963, 1964; Wilson, 1975). It's only a critical problem for the conservative, patriarchal, neoclassical economists who ignore and forget how much time and effort their grandmothers and mothers, aunts and wives, partners and companions are investing in childcare, eldercare, and homecare while they pursue their academic careers. The conservative, patriarchal, neoclassical economists gloss over the classical deist ethos of Smith's deist logic as outlined in his earlier study, *A Theory of Moral Sentiments* (1759). Similarly, the conservative, patriarchal, neoclassical sociobiologists gloss over the modern progressive ethos of Darwin's progressive logic as outlined in his later study, *The Descent of Man* (1871). As a result, altruistic behavior becomes "the central theoretical problem" of conservative, patriarchal, neoclassical sociobiology. Ironically, Hrdy herself is a dedicated sociobiologist who studied with Trivers and Wilson at Harvard. And yet instead of a mechanist-cybernetic theory of selfish genes, she develops an evolutionary-behaviorist theory of cooperative breeding. In other words, the logic of the natural science of genetics, the grammar of the social science of economics, the rhetoric of the human science of semiotics—as articulations-representations-interpretations of the relative signifying relations of exchange—are inextricably entangled in both the conservative-formalist and progressive-critical narratives of evolutionary theory.

Then again, no one has ever found a gene that codes for altruism, or a gene that codes for selfishness. The Hellenic Gnostics—who synthesize Zoroastrianism, Judaism, Christianity, neo-Platonism—project a supreme god of goodness and light into the highest heavens and a demiurge god of evil and darkness into the lower heavens. The Modern Sociobiologists—who synthesize Darwinism, Population-Statistical Genetics, Molecular-Chemical Genetics, Mechanist-Cybernetic Genetics—project a demiurge gene of altruism and cooperation into the median depths and a supreme gene of selfishness and competition into the deepest depths. The Gnostics struggle throughout their lives with the forces of good and evil, light and dark. The Sociobiologists struggle throughout their lives with the forces of altruism and selfishness, reciprocity and hoarding. In short, the modern scientific mimetic hierarchy of gene→genotype→phenotype transposes, transforms and inverts the classical mythic mimetic hierarchy of essence→form→appearance. Similarly, the modern scientific mimetic hierarchy of structure→function→phenomenon transposes, transforms and inverts the classical mythic mimetic hierarchy of metaphysics→physics→dialectics.

In this context Peirce's definition of the three branches of semiotics can help us trace the evolutionary history of the Classical, Darwinian and Modernist mimetic hierarchies: i.e. Classical essential-logic→formal-grammar→apparent-rhetoric becomes Darwinian species-logic→variety-grammar→difference-rhetoric which becomes Modernist genetic-logic→ genotypical-grammar→ phenotypical-rhetoric. And that evolutionary history reminds us that the mechanist-cybernetic school of sociobiology is yet another articulation of the so-called structural "paradigm" (Kuhn, 1962)—a term that is itself a structural metaphor—that coalesced in the mid-twentieth-century sciences. The structural "paradigm" is based on the binary logic of the binary exchanges of the binary neuron, mind, phoneme; binary kin, clan, culture; binary code, equation, computer; binary helix, gene, behavior; etc. Similarly, the binary logic of self-interest and communal-interest, supply and demand, cost and benefit defines the binary rationality of the capitalist market—according to the classical and neoclassical theories of economics. And, as a heuristic gambit, the structural "paradigm" has led to all kinds of insights.

The sociobiologists (Dawkins, 1976; Hamilton, 1963, 1964; Wilson, 1975), for example, analyze the structural logic of cybernetic genes, which the cognitive psychologists (Barkow, Cosmides, Tooby, 1992) suggest generates the functional grammar of algorithmic modes, which the memetic philosophers (Blackmore, 1999; Dennet, 1995; Sperber, 1996) suggest generates the phenomenal rhetoric of viral memes. In short: cybernetic-genes→ algorithmic-modes→viral-memes. And so, once again, the sociobiologists, cognitive psychologists, memetic philosophers transpose, transform and invert the classical mimetic hierarchies-registers-levels of metaphysical-essential-logic→physical-formal-grammar→dialectical-apparent-rhetoric with their modern mimetic hierarchies-registers-levels of structural-genetic-logic→functional-modal-grammar→phenomenal-memetic-rhetoric.

And yet there's another reason why no one has ever found a gene that codes for altruism or a gene that codes for selfishness. Just as Darwin realizes that he can't actually define a species, so too several leading geneticists realize that they can't actually define a gene. Should it be defined in the terms of its structural configuration, functional operation, phenomenal articulation? Should it be defined in the terms of its chromosomal location, cellular manifestation, somatic generation? What parts of DNA are parts of a gene, what parts of DNA are not parts of a gene? Just as Darwin ultimately abandons the search for "…the undiscoverable essence of the term species" (1998: 392), so too several leading geneticists now argue that "…a simple and universally accepted definition of the gene *never* existed" (Rheinberger and Müller-Wille, 2017: 4; cf. Griffiths and Stotz, 2013). That is, the more closely we examine the clue of identity, the more quickly it diffuses into a cluster of similarity and a cloud of difference.

Darwin falls back on the fuzzy logic of analogy and averages in order to develop his working definition of a species and the geneticists fall back on that same fuzzy logic in order to develop their working definition of a gene. As Wagner and Tomlinson put it, "A coding gene, then, is not a discrete material element, but a segment of a more extensive DNA molecule that includes a number of functional elements such that the segment is used by the cell to produce a certain protein" (2022: 6). In fact, instead of thinking in the terms of individual genes, Dupré and Nicholson (2018) explain that, "The development of most traits is now understood to involve features widely distributed across the genome as well as influences from many aspects of the external environment" (2018: 32). So, once again, we return to the great mystery wrapped in the great enigma that lies at the heart of Darwin-Wallace-Mendel's great theory of evolutionary biology. If an *origin* is undefinable, a *species* is undefinable, a *gene* is undefinable, then one undefinable thing can't be used to define another undefinable thing. In other words, as the post-modern interpretation of the pre-modern Hindu myth suggests, if the flat earth rests on the back of a turtle and if that turtle rests on the back of another turtle, then it's turtles all the way down.

No wonder, then, that in response to the critical questions of selection and innovation, evolution and theory, thinking and writing raised by Darwinian Theory and the Modern Synthesis, some evolutionary biologists propose an Extended Evolutionary Synthesis. They shift the orientation and focus of evolutionary biology yet again from the mimetic hierarchies of species→varieties→differences and genes→genotypes→phenotypes to the mimetic interactions of organisms←→developments←→ecologies (Jablonka and Lamb, 2020; Lala *et al.*, 2015; Müller, 2017). In this context the developmental biologists suggest that since an organism actively constructs its niche, then it actively alters the ecological parameters of natural selection—and thus it actively alters the evolutionary development of its species. And if we recognize culture itself as a constructed social niche, then we can understand why the developmental biologists continue to extend their extended theory of an evolutionary feedback loop with further studies of evolutionary culture (Lala, 2017), evolutionary consciousness (Ginsburg and Jablonka 2019; 2022), evolutionary causation (Uller and Lala, 2019) and other key topics.

In turn again, in response to these same critical questions, some evolutionary biologists propose an Integrative Evolutionary Synthesis. Instead of *extending* the Modern Synthesis they want to *replace* it with a biosemiotic theory of the mimetic interactions of systems←→networks←→dynamics (Barbieri, 2008; 2019a; 2019b; Favareau, 2010; Hoffmeyer, 1996; 2002; 2008; Noble, 2012; 2016; 2021). The integrative biologists draw on Pierce's semiotic theory in order to study the natural codes of the natural world. And so they argue against analytic reductionism and they argue for synthetic complexity. Noble (2021), for example, suggests that there is no privileged level of codes. Instead of reducing biological complexity to sociobiological genetics, an integrative biosemiotics re-connects every part of a biological system via the feedback loops of its interactive networks. In this context Noble proposes a multilevel theory of "biological relativity" analogous to Einstein's multilevel theory of "general relativity" (2021: 12; 2016; 2012).

In turn yet again, in response to these same critical questions, some evolutionary biologists propose a Processual Evolutionary Synthesis. Instead of beginning with species, genes, organisms, or systems, they begin with the mimetic interactions of processes←→hierarchies←→dialectics. Specifically, the process biologists study the "hierarchies of processes" which "in broadly mereological terms" range from "molecules, cells, organs" to "populations"—and "cultures" (Dupré and Nicholson, 2018: 3). And so they argue that "energy flows," "life-cycles" and "ecological interdependence" account for both the persistent stability and the ongoing changes of "thing-like" biological entities (2018: 3-4). In this context they trace the history of process philosophy from Heraclitus' "everything flows" (ca. 500 B.C.) to Hegel's "dialectic of mind" (1807) and then again to Whitehead's "process and reality" (1929). In turn, they explain how that philosophical tradition inspires the 20th century organicist biologists who, in turn again, inspire their theory of process biology (Dupré, 2021; Dupré and Nicholson, 2018: 3-45; Nicholson and Gawne, 2015: 345-81). And yet J. Jaeger notes that process biology also emerges from quantum physics. He cites Bohm's suggestion that, "'There is really no 'thing' in the world'" (2018: *xi*; 1999: 12). Instead of focusing on essential *things*, the quantum physicists and process biologists focus on relative *relativities* and dialectical *processes*. And so Dupré and Nicholson offer a pragmatic-functionalist definition of their theory: "…processes are individuated…by what they do. A series of activities constitute an individual process when they are causally interconnected or when they come together in a coordinated fashion to bring about a particular end" (2018: 13).

In short, Darwin analyzes the natural selection of species; the Modern Synthesizers analyze the generative structures of genes; the Extended Evolutionary Synthesizers analyze the developmental interactions of organisms; the Integrative Evolutionary Synthesizers analyze the biosemiotic relativity of systems; and the Processual Evolutionary Synthesizers analyze the dialectical hierarchy of processes. I can't do justice here, in the limited space of this essay, to the sophisticated complexity of these five key theories of evolutionary biology, or to the profound insights and critical discoveries they have enabled. In any case, I don't have the requisite expertise necessary for that kind of review. Instead, I'm asking radical questions about the semiotic presuppositions that underwrite these five key theories. And, in this context, I'm outlining the different ways in which they transpose, transform and invert the classical mimetic hierarchies-registers-levels of essence→form→appearance: i.e. species→variety→difference; gene→genotype→phenotype; organism ←→development←→ecology; system←→network←→dynamic; process←→hierarchy←→dialectic. I'm suggesting that these five key theories articulate five different implicit and explicit mimetic economies of exchange that link their respective hierarchies-registers-levels. And I'm noting that as these five key theories evolve, they shift the focus of evolutionary biology from essential things to relative relations. As a result, they lead to a sixth key theory of the long evolutionary history of the relative signifying relations of exchange.

3. Exchange

Heraclitus (ca. 500 B.C.) declares, "All things are an equal exchange for fire and fire for all things, as goods are for gold and gold for goods" (Kirk and Raven, 1971: 199; cf. Waterfield, 2009: 42). As a radical pre-Socratic philosopher, Heraclitus suggests that fire is the fundamental element of nature and gold is the fundamental element of culture. And yet, more astutely, he suggests that exchange is a universal dynamic that connects nature and culture. So instead of focusing on Heraclitus' elemental nouns, "fire" and "gold," we can focus on his dynamic verb, "exchange." Similarly, instead of focusing on Klein's essential nouns, "gene" and "species" we can focus on his dynamic verb, "exchange." In fact, Heraclitus anticipates Einstein by approximately twenty-four-hundred years: F = T (ca. 500 B.C.) becomes $E = mc^2$ (1905). Instead of Heraclitus' "fire," we have Einstein's "energy;" instead of Heraclitus' "things," we have Einstein's "mass." And we can note that both theories begin with the binary signifying relations of exchange: fire←→things and energy←→mass.

Since the binary signifying relations of exchange are the most basic kind of signifying relation of exchange—it takes two to tangle and two to tango—then they have evolved the basic binary symmetries of the natural world: e.g. helixes and bodies. They have evolved the basic binary theories of the structural sciences: e.g. genetics and cybernetics. And they have evolved the basic binary forms of the mathematic equation: e.g. 2 + 2 = 4 and $E = mc^2$. The so-called equal sign in Einstein's so-called equation, therefore, isn't a sign of identity—it doesn't mean that energy *is-the-same-thing-as* mass times the speed of light squared. If that were the case, then every so-called equation in every modern science would be a tautology—a repetition of the identity of identity—and it wouldn't teach us anything new. Instead, the so-called equal sign in every so-called equation shouts, "THIS can be EXCHANGED for THAT!" It not only articulates the relative relativity of the non-identity of non-identity, but also the relative relativity of the value-of-value of each so-called thing being exchanged.

The so-called equal sign in Einstein's so-called equation, therefore, reminds us that energy can be exchanged for mass and mass for energy. It reminds us that energy can be understood as temporalized mass and mass can be understood as spatialized energy. While our empiric-analytic discourses break down the hard facts of the natural world into distinct categories, like "energy" and "mass," leaving us to discover their signifying relations, our semiotic-synthetic discourses begin with the signifying relations of the natural world, like "energy←→mass ←→mass←→energy," enabling us to trace their evolutionary histories. In this context we can re-interpret the so-called equal sign in every so-called equation as a trail marker in an algorithmic narrative of exchange that articulates-represents-interprets the relatively relative signifying relations of exchange—like the linguistic narrative of this proof. And so we can recognize that writing with numbers, symbols, letters and/or words about exchange is itself a reflexive practice of exchange.

In fact, we are exchanging one word for another word in the displaced time where and when I am writing these words and in the displaced time where and when you are reading them. And these extended reciprocal signifying practices of exchange evolve these extended reciprocal signifying relations of exchange which evolve these extended reciprocal signifying pathways of exchange which evolve this extended reciprocal signifying narrative of exchange which evolves this extended reciprocal signifying proof of exchange. Instead of thinking in the terms of synchronic binary equal signs and binary equations, therefore, we can think in the terms of diachronic algorithmic pathways and algorithmic narratives. In other words, the binary signifying relations of exchange are only one kind of signifying relation—and they can't be separated from their evolving ecologies of exchange. The analytic reduction of the relative signifying relations of exchange to their spatial binary structures belies their temporal fluid dynamics. As a result, the structural theories of the structural sciences belie the evolutionary theories of the evolutionary sciences.

The 17th, 18th, 19th century natural histories give way to the 20th century natural sciences when the focus of scientific analysis shifts from the so-called surface level of diachronic sequences to the so-called deep level of synchronic systems: e.g. structural mathematics-physics-chemistry-genetics, etc. The same is true of the 20th century social sciences: e.g. structural anthropology-sociology-history-economics, etc. And the same is true of the 20th century human sciences: e.g. structural psychology-philosophy-aesthetics-linguistics, etc. No wonder, then, that many 21st century natural scientists are still struggling to re-integrate the mimetic hierarchies-registers-levels of deep-structural-logic (e.g. genes), median-functional-grammar (e.g. genotypes), surface-phenomenal-rhetoric (e.g. phenotypes) in the mimetic economies of their scientific methodologies. And yet we shouldn't substitute method for theory, or theory for method. Instead, like Socrates, we should ask radical questions—especially about the so-called paradigms of truth.

In this context I suggest that we can replace the so-called equal sign, "=," in every so-called equation with the exchange sign: "←→." Instead of repeating the misnomer, "equation," we can employ the word, "algorithm," as in the phrase, "algorithm of exchange." Every so-called equation—and every rightly-named algorithm—is just a tiny fragment of the long evolutionary history of the relative signifying relations of exchange. A so-called equation represents just one signifying relation of exchange, or just a few signifying relations of exchange. It represents just a few signifying numbers, symbols, letters excised from the long, complex, hieroglyphic narrative of the long, complex, evolutionary history of the relative signifying relations of exchange that articulates this 13.7 billion year old universe. In this context we can recognize the relative relativity of the non-identity of non-identity. We can re-configure Darwin-Peirce-Einstein's *special theories* of evolution-semiosis-relativity in a *radical theory* of exchange←→signification ←→value. Then we can use that new *radical theory* of evolutionary semiotics to write a new *general theory* of evolutionary history.

Peirce (1906) suggests that, "The entire universe is perfused with signs, if it is not composed exclusively of signs" (*CP*, 1958: 5.448). And that's why, in a letter addressed to Lady Welby (1908), he explains that,

> It has never been in my power to study anything—mathematics, ethics, metaphysics, gravitation, thermodynamics, optics, chemistry, comparative anatomy, astronomy, psychology, phonetics, economics, the history of science, whist, men and women, wine, metrology, except as a study of semeiotic. (Weiner, ed., 1958: 08)

Instead of suggesting that human beings are god-like signifying subjects who bestow god-like signifying meanings upon stone-like meaningless objects—i.e. the universe—Peirce suggests that both human beings and the universe are sign-like articulations of *never-ending-semiosis*. Instead of the Copernican universe centered by the sun, the Peircean universe is decentered by the sign. And that proposition leads Peirce to ask: How does the dialectical-semiotic mind engage the evolutionary-semiotic universe? He answers that question with his dialectical-semiotic theory of object←→representamen←→interpretant. We become aware of an object through its signifiers and then, as members of a particular community of interpreters, we interpret those signifiers until we arrive at a consensus of truth about them. In turn, we ourselves are signifiers whose significations are further interpreted by our own community and by other communities. And so we pedal our dialectical-semiotic tricycles, with their wheels within wheels, into the future (cf. Hookway, 1985).

In this context Peirce argues that we only know ourselves, others and the world around us via the signifiers we are in the process of individually and collectively interpreting (cf. Buchler, 1955: 98-119; Rodríguez Higuera, 2023). As Colapietro (1989) notes, "…for Peirce, the repudiation of the Cartesian starting point means the recovery of flesh-and-blood actors who are continuously defining themselves through their give-and-take relationships with both the natural world and each other" (1989: *xix*). In effect, Peirce re-grounds Descartes' (1637) structural-logical rationalist epistemology, Kant's (1781) functional-grammatical formalist epistemology and Hegel's (1807) phenomenal-rhetorical idealist epistemology in his dialectical-semiotic "pragmaticist" epistemology.

Then again, Peirce's special theory of dialectical semiotics, i.e. his pragmaticist epistemology, is inseparable from his general theory of evolutionary semiotics, i.e. his universal cosmology. He argues that everything in the universe already "stands" in a signifying relation to everything else and so these signifying relations don't originate with, or depend upon, our species. The actual interpretants of signifiers are not necessarily the human interpreters of signifiers. In fact, our species, like every other species, is itself a further evolutionary articulation of these signifying relations—and we create new ones. Again, we interpret and re-interpret natural and cultural signifiers until we reach a consensus of truth about them. And, for Peirce's community of interpreters, the logic of logic, logic of semiosis, and logic of science represent the highest forms of truth. However, it's worth noting that, for other communities of interpreters, myth and religion, theology and philosophy, economics and politics, etc. represent the highest forms of truth. In turn, all these communities and interpreters, truths and discourses are, themselves, endlessly interpreted and re-interpreted.

Peirce's father was a highly accomplished professor of mathematics at Harvard and he tutored his young son by setting him mathematical problems. In turn, as a precocious teenager, Peirce began his life-long fascination with the science of logic. In turn again, as a twenty-year-old student, he graduated from Harvard in 1859 with a degree in chemistry (cf. Burch, 2024). No wonder, then, that Peirce privileges the logic of logic, logic of semiosis and logic of science in his analytic essays: he is continuing his conversations with his father. And no wonder, then, that Peirce analyzes the dialectical logic of semiosis in his triadic schemas, catalogues the functional grammar of semiosis in his triadic tables, and engages the phenomenal rhetoric of semiosis in his triadic essays: he is updating the medieval trivium—via Descartes-Kant-Hegel—as the modern trivium. I can't do justice here, in the limited space of this essay, to the richness and complexity of Peirce's mimetic hierarchy and economy of logic→grammar→rhetoric. However, I can note that he never fully re-integrates that mimetic hierarchy and economy in a synthetic narrative. He re-writes Hegel's idealist dialectic of absolute mind←→objective mind←→subjective mind as the pragmaticist dialectic of firstness←→secondness←→thirdness, but he doesn't re-write Hegel's idealist history as a pragmaticist history. He produces hundreds of short analytic essays, but he never completes his long synthetic book, *A Guess at a Riddle*.

In this context I can clarify my definition of exchange ←→signification←→value: "to exchange" means "to put in relation" and therefore "to signify" the relative values of the so-called things being exchanged as well as the relative values of the so-called things exchanging them. In short, the relative signifying relations of exchange articulate the relative value-of-value. They are the natural *interpretant* without necessarily being the cultural *interpreter*. And in this context we can recognize that while the mathematics and physics of the relative signifying relations of exchange evolve the chemistry and biology of them, the earlier articulations don't determine the later articulations and the later articulations can't be reduced to the earlier articulations. And that is precisely because as the relative signifying relations of exchange evolve, they loop back on themselves and articulate new intensities of dynamic integrated complexity. These new intensities, as relatively relative signifying relations of exchange, can't be explained by their objectified parts and they can't be reduced to their objectified parts—or even to their nascent objectified parts. And therefore we can resist the temptation to translate the legitimate discourses of empirical materialism, experimental physics, and logical positivism into the legitimation discourses of every science. So instead of thinking in the reductive terms of essential things—e.g. quantum strings→loops→membranes—we can think in the generative terms of relative relations: e.g. quantum exchanges.

In turn, if the relative signifying relations of exchange articulate the relative value of the so-called things *being exchanged* as well as the relative value of the so-called things that *are exchanging* them, then, as Peirce suggests, the so-called things that exchange signifiers are themselves signifiers. And that explains why the origin has no originality, the species has no specificity, the gene has no genealogy—and the selection has no selectivity. It explains the non-identity of non-identity. However, that doesn't mean that every so-called thing, every so-called one, every so-called value inevitably vanishes into the infinite regression of signification—a post-modern argument that begins, ironically enough, with the pre-modern story of the mythic and biblical, platonic and romantic "fall" from the symbolic plenitude of heaven and nature to the semiotic poverty of earth and culture. Instead, it means that every so-called thing-one-value is no-thing more and no-thing less than a co-incidental articulation of the long evolutionary history of the relative signifying relations of exchange. It means that the relative value-of-value evolves with and evolves as the relative ecologies of exchange. It means that the counter-historical post-modern theory of the infinite regression of signification can be re-configured as an evolutionary-historical contemporary theory of the relative relativity of signification.

The bright color of the golden poison-dart-frog, for example, broadcasts the signal of its toxicity and so *golden* poison-dart-frogs and their *discriminating* predators evolve together in the rainforest via their relative signifying relations of exchange (cf. Dumbacher *et al.*, 2004; Summers and Clough, 2001). The more clearly the population of poison-dart-frogs signal their toxicity, the more fit they become. In turn, the more clearly the population of their predators read the signal of their toxicity, the more fit they become. Similarly, the dull color of the mottled common-pond-frog scatters the signal of its tastiness and so *mottled* common-pond-frogs and their *discriminating* predators evolve together in the wetland via their relative signifying relations of exchange (cf. Houston, 1973). The more obscurely the population of common-pond-frogs hide their tastiness, the more fit they become. In turn, the less obscurely the population of their predators read the signal of their tastiness, the more fit they become. That is, the relative value-of-value of the bright golden color and the dull mottled color evolve via the respective relative histories of their respective relative ecologies of exchange. And if, once again, we extrapolate these arguments, then, once again, we can see that every so-called thing in this so-called universe—e.g. strings, loops, membranes; particles, atoms, molecules; genes, cells, organisms; differences, varieties, species; processes, ecologies, systems; gifts, goods, commodities; words, thoughts, ideas; and the color of frogs—is no-thing more and no-thing less than a co-incidental articulation of the long evolutionary history of the relative signifying relations of exchange. And so is the relative value of their relative value.

While Darwin, Peirce, and Einstein implicitly and explicitly evoke the semiosis of exchange in the course of their theories, they don't begin with it. They don't make it the radical beginning-without-beginning of their theories. So the particular re-alignment of Darwin's evolutionary biology, Peirce's dialectical semiotics, and Einstein's relative physics that I'm proposing in this essay leads to a new radical theory of evolutionary semiotics that leads to a new general theory of evolutionary history. Similarly, while Darwin's successors implicitly and explicitly evoke the semiosis of exchange in the course of their theories, they don't begin with it. They don't make it the radical beginning-without-beginning of their theories. So the particular re-alignment of the Modern Synthesis, Extended Evolutionary Synthesis, Integrative Evolutionary Synthesis, and Processual Evolutionary Synthesis that I'm proposing in this essay also leads to a new radical theory of evolutionary semiotics that leads to a new general theory of evolutionary history. And that new general theory can help us trace the long evolutionary history of the dynamic←→practice←→syntax of natural←→cultural←→historical exchange←→signification←→value. It can help us recognize the varied and prolific relative signifying relations of exchange at work within, between and across all the divisions, sub-divisions, and discourses of all the modern sciences.

4. Sciences

As Heraclitus' aphorism implies, the relative signifying relations of exchange connect all the modern sciences.

In the realm of mathematics, for example, as I've already indicated, every so-called equal sign can be replaced by an exchange sign. Mathematics itself, therefore, can be re-interpreted as a science of the relative signifying relations of exchange. And that explains why Carnap (1937) analyzes the logical "logicist" foundations of mathematics; von Neumann (1925) analyzes the grammatical "formalist" foundations of mathematics; Heyting (1956) analyzes the rhetorical "intuitionist" foundations of mathematics (Benacerraf and Putnam, eds., 1998). They each in turn privilege a different mimetic level of mathematic signification. In effect, they re-read the modern foundations of mathematics as yet another modern version of the medieval trivium: i.e. the logic-grammar-rhetoric of the structure-function-phenomenon of exchange-signification-value. No wonder, then, that the semiosis of exchange is evident on every analytic level of the science of mathematics.

Similarly, in the realm of quantum physics, G. Jaeger (2021) cites Wilczek's (1999) summary review of 20th century quantum physics: "'The association of forces (or, more generally, interactions) with the exchange of particles is a general feature of quantum field theory'" (2021: 2). And yet Jaeger goes on to note that "…the current received view in the foundations of QFT [is] that quantum particles, in general, cannot be well defined and that defining particles which could mediate force is additionally problematic…" (2021: 2). Since the quantum field theorists can't precisely define the quantum particles that delimit a quantum field or the quantum particles that mediate the quantum forces of that quantum field, then the familiar association of force and exchange in quantum physics has been thrown into question (2021: 3). Darwin's heirs can't precisely define a species, Mendel's heirs can't precisely define a gene and Heisenberg's heirs can't precisely define a particle. How does Jaeger solve the problem? In effect, he follows his predecessors' lead by developing his own version of fuzzy logic, fuzzy grammar, fuzzy rhetoric. He suggests that quantum particles aren't really particles *per se*, instead they are "compresent collections of properties" at play on the quantum field (2021: 4). And that fuzzy definition of quantum particles enables Jaeger to re-affirm the idea that "…exchange forces correctly describe and explain an overwhelming majority of currently known atomic and subatomic phenomena…" (2021: 4). In turn, Jaeger's argument can be taken a step further. I suggest that quantum particles—like species, genes, organisms, systems, processes—are no-thing more and no-thing less than co-incidental articulations of the long evolutionary history of the relative signifying relations of exchange, beginning-without-beginning with energy←→mass ←→ mass←→energy. That is, quantum particles are not only *mediators* of exchange forces, but also *articulations* of them. And therefore their relative significance-force-value evolves from their relative signifying relations of exchange. No wonder, then, that the semiosis of exchange is evident on every analytic level of the science of physics.

Similarly, in the realm of chemistry, chemical exchange reactions articulate another basic kind of signifying relation. The definition of a chemical exchange reaction can be found in any introductory text: e.g. "An exchange reaction is a chemical reaction in which both synthesis and decomposition occur, chemical bonds are formed and broken, and chemical energy is absorbed, stored and released" (Biga *et al.,* 2019). And, again, "Exchange reactions are those in which cations and anions that were partners in the reactants are interchanged in the products." This kind of double-displacement exchange reaction can be written as the formula, "AB + CD → AC + BD," and its variants. So, for example, "NaCL (sodium chloride) + $AgNO_3$ (silver nitrate) → $NaNO_3$ (sodium nitrate) + AgCL (silver bromide)" (U. Wisc. Chem. Dept., n.d.; cf. Clayden *et al.*, 2012). As the first definition suggests, exchange reactions, synthesis reactions, decomposition reactions, etc. are all dynamically interactive. The formula, H_2 + O = Water, for example, represents a synthesis reaction of shared electrons. In turn, that synthesis reaction interacts with certain exchange reactions—and with other reactions and other chemicals—in certain combinations and circumstances which generate the precursor organic compounds of life on Earth. Miller and Urey (1953; 1959) famously cook up a laboratory version of the primeval recipe by combining water vapor, methane, ammonia, hydrogen and jolting the atmospheric mixture with an electric arc. No wonder, then, that the semiosis of exchange is evident on every analytic level of the science of chemistry.

Similarly, in the realm of biology, the basic metabolism of every living organism articulates the universal exchange relations of energy←→mass ←→ mass←→energy. Every living organism absorbs or ingests some kind of energizing nutrient which it converts into other kinds of energizing physicality and activity. In fact, the relative signifying relations of exchange evolve and articulate every critical signifier of life—e.g. homeostasis, organization, metabolism, growth, information, reaction, interaction, adaptation, genetics, reproduction, evolution, etc. (Malaterre and Chartier, 2019). And, therefore, life itself, as a noun-thing-state, remains difficult, if not impossible, to define (Zimmer, 2021). As I've noted, throughout his great book Darwin marvels at the mutual relations of nature which, I'm suggesting, can be recognized as further examples of the relative signifying relations of exchange. He notes that "…plants and animals…are bound together by a web of complex relations" and so, for example, "Many of our orchidaceous plants absolutely require the visits of moths to remove their pollen-masses and thus to fertilise them" (1998: 61). He concludes, therefore, "…that the structure of every organic being is related…to that of all other organic beings" in its network of relations (1998: 64). No wonder, then, that the semiosis of exchange is evident on every analytic level of the science of biology.

Similarly, in the realm of genetics, the exchange of genetic codes—e.g. microorganism←→microorganism, plant←→plant, animal←→animal, species←→species—and the recombination, variation, mutation, modification and selection of them in subsequent generations represent another basic dynamic of nature and a key dynamic of evolution. As I've noted, the Modern Synthesis combines Darwin's theory of natural selection and Mendel's theory of genetic inheritance in a series of groundbreaking studies that includes mechanist-cybernetic genetics, molecular-chemical genetics, population-statistical genetics among others. And along with the powerful evolutionary forces of genetic descent with variation, Anderson (1949) and Arnold (2015) argue for the powerful evolutionary forces of genetic transference with variation. They suggest that genetic transference among diverging species evolves new hybrids. In this context Arnold argues for *Evolution through Genetic Exchange* (2007). And in this context, once again, a radical theory of genetic exchange explodes the conservative theory of essential species. I should also note that, for the so-called higher animals, the nexus of genetics, sexuality, desire, life, death generates some of the most powerful narratives of exchange—the stuff that dreams and nightmares are made of. No wonder, then, that the semiosis of exchange is evident on every analytic level of the science of genetics.

Similarly, in the realm of neurology, the nerve network, neural network, and synaptic network are further articulations of the physical-chemical-biological—and electrical—exchange relations of complex biological organisms. Specifically, "…synaptic AMPA-R exchange is essential for maintaining the capacity for bidirectional plasticity" (McCormack *et al.*, 2006). That is, electrochemical, strong or weak, excitatory or inhibitory signals don't just flow in one direction from neuron to neuron, rather they flow in both directions. In fact, they flow in multiple directions to and from multiple neurons. And therefore "…synaptic plasticity is the 'hub,' as it directs subcellular plasticity with regional specificity, and underlies much of circuit-level plasticity" (Brown *et al.*, 2022). In the human brain the semiotic plasticity of the "…86 billion neurons [which] form 100 trillion connections to each other" opens up the countless possibilities of what Lee (2023) calls "connectomics" (Caruso, 2023; Nguyen *et al.,* 2023). No wonder, then, that the semiosis of exchange is evident on every analytic level of the science of neurology.

Similarly, in the realm of ecology, the exchange relations that evolve an ecosystem represent yet another pervasive dynamic of nature. An ecosystem can be described as the cumulative temporal-spatial and local-global "interactions among organisms and their environments" (Chapin, *et al.* 2011: 3). And these terrestrial interactions usually begin with the exchange of the sun's energy and the earth's mass (Chapin *et al.* 2011: 11). In other words, an ecology of exchange evolves an ecosystem of exchange—and vice versa. In the famous concluding paragraph of *On the Origin of Species* (1859), for example, Darwin notes that,

> It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us. (1998: 395)

Again, the ecological phrase, "dependent on each other in so complex a manner," can be more precisely stated with the semiotic phrase, "articulating the relative signifying relations of exchange in so complex a manner." And while Darwin begins his concluding paragraph with the peaceful exchanges of natural ecology, he quickly returns to the violent exchanges of natural selection: "Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely the production of the higher animals, directly follows." Darwin ends his great book with the "grandeur in this view," with a final nod to the "Creator," and with an evocation of the "forms most beautiful" that "are being evolved." (1998: 396). That is, ever mindful of the death of his young daughter, Anne, in 1851, and the faith of his devout wife, Emma, in 1859, Darwin heroically struggles to balance the tragic and comic ethos of his evolutionary-biological narrative. In turn, Darwin's successors analyze the varied ecological economies of exchange to which they assign different names: e.g. molecular ecology, plant geography, animal ecology, species distribution, biodiversity, ecological communities, ecological statistics, ecological networks, biomes, habitat analysis, food webs, predator-prey ratios, biogeography, keystone species, social ecology, human ecology, cultural ecology, urban ecology, climatology, environmentalism, global warming, etc. (Chapin, *et al.* 2011; Kormondy, 1978; Real and Brown, 1991; Worster, 1994). No wonder, then, that the semiosis of exchange is evident on every analytic level of the science of ecology.

Similarly, in the realm of economics, Smith (1776), Marx (1867) and their heirs analyze the capitalist and communist relations of exchange. Smith, for example, states that the division of labor arises from the human "…propensity to truck, barter, and exchange one thing for another" (1976: 17). And, as I've noted, Smith goes on to argue that the deist logic of the capitalist market transforms self-interest into communal-interest. In turn, Marx suggests that since, by definition, the commodity isn't produced for its immediate use-value, but for its mediated exchange-value, then, "The exchange of commodities begins where [primitive] communities have their boundaries…with other communities…" (1976: 182). In other words, Marx develops the postlapsarian argument of Rousseau and suggests that the commodity is the poison apple in the communal garden. The retrojection of commodity exchange from the border of the primitive community back into the heart of the primitive community signifies the beginning of the inevitable "fall" of "man" from the symbolic plenitude of primitive communism (i.e. immediate use-value) to the semiotic poverty of modern capitalism (i.e. mediated exchange-value). As a result, commodity exchange leads to class division, economic exploitation, worker alienation and the master/slave hierarchy. In this context Marx "scientifically" re-engineers Hegel's idealist-dialectical history machine as a materialist-dialectical history machine. He argues that the dialectical gears of materialist history, i.e. the ongoing class struggle for control of the modes of production, will re-generate the symbolic plenitude of primitive communism on a higher level. That is, the dialectical revolution will enable the workers to reclaim their means of agency and their modes of production. While Smith shifts the focus of analysis from the social relations of exchange to the deist logic of the market, Marx shifts it to the dialectic logic of production. In turn again, Smith's arch-conservative heirs use his deist comedy to legitimate the deregulation of the market economy, while Marx's arch-radical heirs use his dialectic romance to legitimate the dictatorship of the command economy. As a result, the capitalist plutocrats rule The New York Stock Exchange while the communist princelings rule The Shanghai Stock Exchange. In turn, they empower the autocrats of state-capitalism and the emperors of state-communism. And in this way the new state-capitalism gives birth to neo-fascism and the new state-communism gives birth to neo-totalitarianism. No wonder, then, that the semiosis of exchange is evident on every analytic level of the science of economics.

Similarly, in the realms of sociology and anthropology, Simmel (1900), Malinowski (1922), Mauss (1925), Lévi-Strauss (1949), Foucault (1966), Derrida (1991) and their heirs analyze, respectively, the phenomenal, functional, structural and post-structural exchange relations of, respectively, money, gifts, women, words, things, signifiers, etc. In turn, Homans (1958), Goffman (1959), Emirbayer (1997) and many others study the behaviorist, dramatic and transactional social relations of exchange. In turn again, Bakhtin (1934-41) famously analyzes the dialogic imagination. Simmel (1900), for example, proposes that, "…most relationships between people can be interpreted as forms of exchange" (1990: 82). Malinowski (1922) notes that, "The *Kula* is a form of exchange…carried on by communities inhabiting a wide ring of islands which form a closed circuit" (1984: 81). Mauss (1925) suggests that, "…the system in which individuals and groups exchange everything with one another constitutes the most ancient system of economy and law that we can find…." (1990: 70). Lévi-Strauss (1949) argues that, "Exchange, as a total phenomenon, is from the first a total exchange, comprising food, manufactured objects, and…women" (1969: 61). Foucault (1966) states that "…all the kinds of wealth in the world are related to one another in so far as they are all part of a system of exchange" (1973: 179). And Derrida (1991) declares that, "…one must also remember first of all that language is as well a phenomenon of gift-countergift, of giving-taking—and of exchange" (1990: 81). In short, these cultural theorists explore how the social relations of exchange distinguish and disrupt pre-modern communities and modern societies. No wonder, then, that the semiosis of exchange is evident on every analytic level of the sciences of sociology and anthropology.

Similarly, in the realms of politics and government, social contract theory outlines the basic principles of exchange that define the modern state. Hobbes (1651), for example, argues that since men in their natural state engage in "a warre of every man against every man" (1991: 90), then men in their cultural state must exchange their personal prerogatives for their collective security. They must say to each other, "I Authorise and give up my Right of Governing my selfe, to this Man, or to this Assembly of men, on this condition, that thou give up thy Right to him and Authorise all his actions in like manner" (1991: 120). In contrast, Locke (1690) argues that since men in their natural state are free and equal (1952: 4-11), then men in their cultural state will only exchange their natural liberty for their civil liberty. He declares, "The only way whereby any one divests himself of his natural liberty…is by agreeing with other men to join and unite into a community for their comfortable, safe, and peaceable living one amongst another…" (1952: 54). And it is precisely through the mutual consent of the social contract that the natural law of liberty becomes the civil law of liberty. In turn, Rousseau (1755) argues that since men in their natural state are independent noble savages, then men in their cultural state will only exchange their natural independence for their civil liberty. He (1762) asserts that when men consent to put themselves under "the direction of the general will" (1994: 55), they are "…exchanging an uncertain and precarious mode of existence for a better and more secure one, natural independence for liberty" (1994: 70). In effect, Hobbes privileges the executive-monarchic logic of exchange; Locke privileges the legislative-democratic grammar of exchange; Rousseau privileges the normative-demographic rhetoric of exchange. And the debate over the basic mimetic principles of the social contract continues to this day (cf. Lessnoff, 1990; Thrasher, 2020). No wonder, then, that the semiosis of exchange is evident on every analytic level of the sciences of politics and government.

Similarly, in the realms of linguistics and semiotics, Saussure (1916) explains how the relative signifying relations of exchange articulate the relative value-of-value:

> To determine the value of a five-franc coin… what must be known is: (1) that the coin can be exchanged for a certain quantity of something different, e.g. bread, and (2) that its value can be compared with another value in the same system, e.g. …a one-franc coin…. Similarly, a word can be substituted for something dissimilar: an idea. At the same time it can compared to something of like nature: another word. (1989: 113-114)

Saussure suggests that coins, bread, words, ideas don't *possess* an *essential* cultural significance-value-force, rather they only *articulate* a *relative* cultural significance-value-force in and through the relative signifying relations of exchange. However, Saussure goes on to suggest that the meaning of a word is "…determined in the final analysis… as an element in a system…." (1989: 114). That is, Saussure shifts the focus of analysis from the temporal relations of exchange to the spatial systems of structure. In fact, he is the founding father of 20th century structural linguistics. And so I'm using the words, "significance," "value," "force" here in their temporal relatively-relative Peircean and Saussurean sense instead of in their spatial formalist-schematic or spatial formalist-structural Peircean and Saussurean sense. That is, I'm drawing on different aspects of their theories in order to advance their theories. No wonder, then that the semiosis of exchange is evident on every analytic level of the sciences of linguistics and semiotics.

Similarly, in the realm of evolutionary history, I'm suggesting that the co-incidental articulations of the relative signifying relations of exchange evolve every so-called thing-one-value in nature and culture. The specific examples that I'm citing throughout this essay, therefore, represent the beginning of an outline of a new, reflexive, semiotic theory of the long evolutionary history of the relative signifying relations of exchange—ranging from mathematics and physics to chemistry and biology, genetics and neurology, ecology and economics, sociology and anthropology, politics and government, linguistics and semiotics, evolution and history, etc. And in this way I'm building an evolutionary-historical-syntactic-temporal-narrative-bridge that not only reflexively re-connects all the sciences, but also reflexively re-connects all the exchanges of energy←→mass←→time←→space←→force←→particle ←→atom←→element←→star←→planet←→galaxy←→ universe←→molecule←→gene←→cell←→organism ←→ecology←→environment, etc. from the primordial past to the distant future. No wonder, then, that the semiosis of exchange is evident on every analytic level of the science of evolutionary history.

I could cite dozens, if not hundreds, of other examples of the archetypes-algorithms-allegories of exchange: e.g. cooperative game theory (Axelrod, 1984; von Neumann and Morgenstern, 1944); cybernetic information theory (Floridi, 2019; Shannon and Weaver, 1949); network analysis theory (Barabási, 2016; Easley and Kleinberg, 2010; Newman, 2018; Willer, 1999); artificial intelligence theory (Hinton *et al.*, 2006; Rosenblatt, 1958; Turing, 1950), etc. Similarly, Freud (1923) famously outlines a psychodynamic economy of the logic-grammar-rhetoric of exchange: superego←→ego←→id. Then again, Wittgenstein attempts to define the pure logic of logic in *Tractatus Logico-Philosophicus* (1921); the pure grammar of grammar in *Philosophical Grammar* (1931-34) and the *Blue and Brown Books* (1933-35); and the pure rhetoric of rhetoric in *Philosophical Investigations* (1953). He begins with logical propositions, continues with grammatical relations and ends with rhetorical games. Just as Carnap, von Neumann and Heyting privilege one mimetic level of mathematic signification after another, so too Wittgenstein privileges one mimetic level of philosophic signification after another. If—as a general theory of evolutionary history suggests—every so-called thing-one-value in this so-called universe is a co-incidental articulation of the relative signifying relations of exchange, then no wonder every discipline, sub-discipline, and discourse of the natural sciences, social sciences, and human sciences can be re-interpreted, on one level, as an allegory of exchange. And that is exactly what I suggest in my book, *…The Time Being: Allegories of Exchange* (2000).

So in the context of a new radical theory of evolutionary semiotics that leads to a new general theory of evolutionary history we can see, once again, that the natural sciences, social sciences, and human sciences themselves can be re-interpreted and re-connected as allegories of exchange. In fact, as I've been suggesting, the Modern Scientific mimetic hierarchy, Natural Science←→Social Science←→Human Science, can be traced back to the Medieval Scholastic mimetic hierarchy, Logic←→Grammar←→Rhetoric, which can be traced back to the Classical Greek mimetic hierarchy, Essence←→Form←→Appearance, which can be traced back to the Ancient Mesopotamian mimetic hierarchy, Anu-the-Sky-God←→Enlil-the-Earth-God←→Ea-the-Water-God (cf. Foster, 1995), which can be traced back to the Traditional African mimetic hierarchy, Olodumare-the-Sky-God←→Oduduwa-the-Earth-God←→Yemonja-the-Water-God (cf. Belcher, 2006), which can be traced back to the Pre-Historic Archetypal mimetic hierarchy, Sky←→Earth←→Water. In short, the logical archetypes of exchange, Sky←→Earth←→Water, evolve the grammatical algorithms of exchange, Sky←→Earth ←→Water, which evolve the rhetorical allegories of exchange, Sky←→Earth←→Water, which evolve the mimetic hierarchies and mimetic economies of language, thought, and culture. No wonder, then, that in the mythical-metaphysical mimetic hierarchies the truth-of-truth resides in the *highest heights* of the logic of heaven,while in the scientific-physical mimetic hierarchies the truth-of-truth resides in the *deepest depths* of the logic of earth.

In this canonical context we can recognize the long evolutionary history of the mimetic hierarchies-registers-levels and economies of modern scientific writing and modern scientific thinking. We can recognize, for example, that the structural-logic of Cartesian binary systems, functional-grammar of Kantian taxonomic categories and phenomenal-rhetoric of Hegelian teleological dialectics—as the mimetic hierarchies-registers-levels and economies of the enlightened mind which evolve the mimetic hierarchies-registers-levels and economies of the modern sciences—represent only one small segment of the long evolutionary history of the archetypes-algorithms-allegories of exchange. And since I'm also writing and thinking within this same canonical tradition, then I'm reflexively re-contextualizing and reflexively re-historicizing Darwin-Peirce-Einstein's special theories of evolution-semiosis-relativity as well as the Modern, Extended,Integrative and Processual special theories of evolutionary biology. And I'm developing these innovative special theories in a new radical theory that begins a new general theory.

A new general theory of evolutionary history, therefore, brings us right back to the critical questions of selection and innovation, evolution and theory, thinking and writing. However, now we can reverse their logical priorities: innovation and selection, theory and evolution, writing and thinking. And in this context we can return to the critical question of time.

5. Time

The recent general theories of evolutionary history that begin with autocatalytic sets (Kauffman, 1995), emergent complexity (Holland, 1998), threshold transitions (Christian, 2004), non-equilibrium thermodynamics (Chaisson, 2006), quantum bits (Lloyd, 2006), energy flows (Spier, 2015), recombinant sequences (Volk, 2017), assembly algorithms (Sharma *et al.*, 2023), etc. have led to many insights. In turn, I'm beginning with the relative signifying relations of exchange. And I'm suggesting that the dynamic of exchange evolves nature, the practice of exchange evolves culture, the syntax of exchange evolves history. In fact, the burgeoning biological literature on "…turn-taking…[as] the exchange of communicative signals…studied in the theoretical framework of 'chorusing'" (Katsu *et al.*, 2019: 99; cf. Ravignani *et al.*, 2019) reveals the interdependence of time and exchange. So a radical theory of that interdependence suggests that time itself can be thought of as no-thing more and no-thing less than the rhythmic syntax of the long evolutionary history of the relative signifying relations of exchange. And that radical theory not only explains the origin of time, but also the evolution of time.

If this universe begins-without-beginning with the relative signifying relations of exchange—e.g. the energy←→mass ←→ mass←→energy of the so-called big bang—and if all the subsequent relative signifying relations of exchange evolve every so-called thing-one-value, then time itself is no-thing more and no-thing less than the rhythmic syntax of the long evolutionary history of the relative signifying relations of exchange. Again, instead of tumbling into the post-modern abyss of signification, a post-millennial theory of evolutionary semiotics explains how the relative signifying relations of exchange evolve the relative historical bridge of energy←→mass←→time←→space←→force ←→particle, etc. It explains the relative relativity of relative relativity. In this way we re-discover the radical temporality of evolutionary time and the radical spatiality of evolutionary space that Darwin's theory invites us to re-discover. And in this way we open up the exploratory pathways that lead beyond the classical mimetic hierarchy of heavenly metaphysics, the modern gravity well of earthly physics and the post-modern infinite regression of watery dialectics.

So we can begin again in the new millennium with a new evolutionary history of the beginning-without-beginning. Instead of beginning with a *post hoc* theory of restrictive selection, we can begin with an *ad hoc* theory of exuberant innovation. As a result, we can explain what Müller calls, "the generative and ordering aspects of morphological evolution" which are "absent from evolutionary theory" (2003: 51). Specifically, we can recognize that it is the relative signifying relations of exchange that are exuberantly innovative. They make possible link after link, connection after connection, pathway after pathway on every so-called level of analysis. And they make possible link after link within the selective restrictions of not making impossible link after link. That is, every relative signifying relation of exchange on every so-called level of analysis opens up a range of further possible relative signifying relations of exchange while it closes down a range of further impossible relations. As the exuberant innovations of possible link after link become increasingly complex, the selective restrictions of impossible link after link become increasingly complex. The more successful links in a particular ecology of exchange are strengthened, while the less successful links are weakened. In other words, the relative values of the stronger and weaker links are relative to their different historical ecologies of exchange. A strong link—or a series of strong links—that isn't even possible in one historical ecology of exchange, for example, might be entirely possible in another historical ecology of exchange. Coral colonies don't evolve in deep oceanic obscurity, but they do evolve in shallow littoral light.

In addition, the so-called intrinsic innovative exuberance and selective restriction of the possible and impossible, strong and weak, successful and unsuccessful relative signifying relations of exchange are inseparable from the so-called extrinsic innovative exuberance and selective restriction of them. That is, a particular set of the relative signifying relations of exchange doesn't evolve in isolation from every other set, rather all the sets and all the interior and exterior analytic levels of all the sets evolve in relation to one another—as do their ecological ranges of possible and impossible, strong and weak, successful and unsuccessful links-connections-pathways. So the inseparable innovative←→selective, exuberant←→restrictive, improvisational←→repetitive *and* intrinsic←→extrinsic, passive←→active, cooperative←→competitive historical ecologies of exchange enable and disable the different possible and impossible, strong and weak, successful and unsuccessful relative signifying relations of exchange. Again, instead of beginning with a *post hoc* theory of natural selection, I'm beginning with an *ad ho*c theory of natural innovation. That is, kangaroos, platypuses, giraffes aren't *post hoc* utilitarian selections of utilitarian nature, rather they're *ad hoc* exuberant innovations of exuberant nature. And so I'm beginning with an evolutionary-historical theory of the ecological ranges of the innovative-selective relative signifying relations of exchange. Polar bears don't evolve in tropical rainforests and Burmese pythons don't evolve in arctic snowfields.

In fact, as Darwin's theory implies, the innovative exuberance of the relative signifying relations of exchange requires these different kinds of selective restriction precisely in order to be creative—otherwise coherent articulations of dynamic integrated complexity wouldn't evolve. Life on earth would, at best, be nothing more than a primordial soup of unlimited possibilities. Then again, as Zimmer (2021) notes, "That question—What is life?—may seem like it's the first and foremost question biologists should answer. And yet it remains unanswered and, perhaps, ultimately unanswerable" (2021: 124). He goes on to cite Szent-Györgyi (1948): "'The noun 'life' has no sense, there being no such thing'" (2021: 180). As a radical theory of Darwin's radical time suggests, particles, genes, species—as well as life, mind, consciousness—are no-thing.

So, the "first and foremost question" for evolutionary biologists—"What is life?"—raises "the first and foremost question" for evolutionary theorists: Why Life? These critical questions are similar to the critical questions: Why kangaroos? Why platypuses? Why giraffes? And again the evolutionary-historical answer to these critical questions begins with the innovative exuberance of the earliest articulations of the relative signifying relations of exchange. In this context I suggest that life-mind-consciousness, the evolutionary mysteries within the evolutionary mysteries, are no-thing more and no-thing less than co-incidental articulations of the long evolutionary history of the innovative exuberance and selective restriction of the relative signifying relations of exchange looping backward on themselves within specific ecologies of exchange for billions of years and spiraling forward—developing new intensities of dynamic integrated complexity. Specifically, I suggest that the long evolutionary history of life-mind-consciousness can be traced from autonomic reactive exchanges to imitative reflective exchanges to innovative reflexive exchanges and back around again. Each new successful exchange leads to a further successful exchange—until it doesn't. Evolutionary history, therefore, is as much about the impossible and failed relative signifying relations of exchange as it is about the possible and successful ones—about the unrealized potential relative signifying relations of exchange as it is about the realized actual ones.

In fact, the long evolutionary history of the relative signifying relations of exchange necessarily combines relatively novel dynamic improvisations and relatively stable static repetitions. Here again we arrive at the evolutionary juncture of nature←→culture←→history. We arrive at the evolutionary juncture of the dynamic integrated complexities of life←→mind←→consciousness—and intelligence. We arrive at the evolutionary juncture of the new "mode of being" defined by the new capacity of "Unlimited Associative Learning" (Ginsburg and Jablonka, 2019; 2022). And that new "mode of being" can be re-interpreted as the new reactive←→reflective←→reflexive intensities of the relative signifying relations of exchange looping backward on themselves as they spiral forward—evolving their new Darwinian and Lamarckian potentialities. So we also arrive at the recent theories of cultural evolution (e.g. Diamond, 1997; Flannery and Marcus, 2012; Geroulanos, 2024; Graeber and Wengrow, 2021; Harari, 2015; Henrich, 2016; Lala, 2017; Lewens, 2015; Mesoudi, 2011; Richerson and Boyd, 2004; Russell, 2011). The relatively new forms of human culture can also be re-interpreted as innovatively-exuberant and selectively-restrictive articulations of the long evolutionary history of the relative signifying relations of exchange—again including the new Darwinian and Lamarckian validation-preservation-accumulation of shared practices-skills-technologies and data-information-knowledge. Our practical signifying exchanges evolve our neural signifying exchanges and our neural signifying exchanges evolve our practical signifying exchanges (Kweon *et al.*, 2023). And that suggestion leads to the long evolutionary history of the reciprocal exchange relations of minds←→minds, cultures←→cultures, and minds←→cultures.

In this context we can continue to trace the evolutionary-historical continuum linking the natural-sciences←→social-sciences←→human-sciences. That is, life←→mind←→ consciousness and language←→thought←→culture are further examples of the many different ways in which the long evolutionary history of the relative signifying relations of exchange loops backward on itself, evolves itself, articulates itself, represents itself, interprets itself—as demonstrated by the relative signifying relations of the very words of this very sentence. In turn, a recent collection of over twenty research papers—published simultaneously in *Science* and its affiliated journals (e.g. Ament *et al.*, 2023; Komiyama, 2023; Maroso, 2023; etc.)—outline a new map of the human brain. As Zimmer (2023) notes, the new map reveals that "…all the cell types in human brains matched up with those found in chimpanzees and gorillas" with slight genetic variations that tweak their functions. He then cites Bakken, one of the lead neuroscientists on the project, who concludes that it's not really the cells *per se*, rather, "'It's really the connections—how the cells are talking to each other—that makes us different from the chimpanzees'" (2023: A23). In other words, once again, it's really the new reactive←→reflective←→reflexive intensities of the relative signifying relations of exchange that make human brains, human minds, human bodies, human beings, human learning and human cultures relatively human. It's really the 86 billion neurons and their 100 trillion relative signifying relations of exchange spiraling forward and looping backward over and again. Instead of employing the mechanist-physicalist-materialist metaphors of brains, wires, connections, therefore, we can employ the fluidic-relativistic-dynamic metaphors of exchange, signification, value. The human brain is a co-incidental articulation of the long evolutionary history of the relative signifying relations of exchange—and it further articulates that long evolutionary history.

So I suggest that the evolutionary relations of exchange evolve the evolutionary algorithms of exchange which evolve the evolutionary ratios of exchange. If, for example, the evolutionary ratios of exchange slide too far toward the dynamic innovative-exuberant range, then *stable* forms of life←→mind←→consciousness and language←→thought←→culture can't evolve. If, for example, they slide too far toward the static selective-restrictive range, then *novel* forms of life←→mind←→consciousness and language←→thought←→culture can't evolve. Stone-age African hominins, for example, got stuck at the too-far-end of the static selective-restrictive range of neural←→cognitive←→social exchange—repeating imitative-reflective practices←→skills←→technologies for millions of years (cf. Klein, 2009). In contrast, modern-age African hominins, for example, got unstuck at the not-too-far-end of the dynamic innovative-exuberant range of neural←→cognitive←→social exchange—inventing generative-reflexive languages←→thoughts←→cultures for hundreds of thousands of years (cf. Klein, 2009). As a result of all these critical factors, therefore, imitative-reflective rote repetition was supplemented and supplanted by generative-reflexive creative invention. In short, I suggest that, as they evolved, the relative signifying relations of exchange evolved the algorithmic ratios of innovative exuberance and selective restriction which evolved the modern human cognitive singularity: i.e. the critical moment when a critical subset of the 100 trillion reactive and repetitive neural exchanges became reflexive and generative neural exchanges and so began to articulate modern human consciousness-language-culture.

In other words, our plastic genetic←→cellular←→somatic exchanges, neural←→cognitive←→social exchanges, linguistic←→economic←→technological exchanges, teaching←→learning←→information exchanges, generative←→improvisational←→inventive exchanges loop backward on themselves and spiral forward into the future. That is, our plastic autonomic-reactive exchanges evolve our plastic imitative-reflective exchanges which evolve our plastic generative-reflexive exchanges as they loop backward on themselves and spiral forward over and again. As a result, these plastic dynamic-practical-syntactic exchanges lead to the new intensities of relatively human culture approximately 100,000 to 50,000 years ago. And the geometric cascade of our generative-reflexive learned-cultural exchanges continues to this day. In the twentieth century, for example, it takes a mere sixty years to get from the Wright brothers' bi-plane to the NASA engineers' lunar lander. It takes a mere forty years to get from Einstein's $E = mc^2$ to the Manhattan Project engineers' atom bomb. And it takes a mere twenty years to get from the end of Kaiser Bill's world war to the beginning of Chancellor Adolf's world war. In short, our species often takes one evolutionary step forward and two devolutionary steps backward.

Similarly, our cybernetic models of machine learning and artificial intelligence are still stuck at the too-far-end of the stone-age level of imitative-reflective repetition. These cybernetic models excel at rote tasks such as data storage, search strategy, pattern recognition, category analysis, linguistic imitation, etc., but they fail at improvisational tasks that require reflexive intelligence. That is, these cybernetic models are mathematically delineated input/output programs—and non-human interpretants, such as other programs and other machines, exchange with them. Similarly, human interpreters also exchange with them. And yet Mitchell (2019) notes that, "…we humans tend to overestimate AI advances and underestimate the complexity of our own intelligence" (2019: 278). She continues, "Today's AI is far from general intelligence, and I don't believe that machine 'superintelligence' is anywhere on the horizon" (2019: 278). However, Mitchell's book was published in 2019—a million years ago in the newly accelerated timescale of generative A.I. What about the more recent cybernetic breakthroughs?

The newer large language models of machine learning and artificial intelligence generate ever more sophisticated recurrent neural networks—but they still aren't reflexively intelligent in any modern-human sense of the phrase. And so Mitchell's (2019) citation of Mullainathan (2014) remains pertinent: "'I am far more afraid of machine stupidity than of machine intelligence'" (2019: 279). What happens, for example, when we sit back in autonomous self-driving cars that aren't really autonomous self-driving cars? What happens when we link autonomous smart-bomb-drones that aren't really smart with autonomous smart-target-algorithms that aren't really smart? What happens when we expand the remit of technology far beyond the range of its capacities? What happens when we anthropomorphize computer programs as a form of so-called artificial intelligence? What happens when we idolize that so-called artificial intelligence as superhuman intelligence? What happens is the A.I. stock-market speculative bubble expands beyond all reason as high-tech and low-tech corporations rush to re-brand everything they are doing as A.I. In short, A.I. = Algorithmic Idolatry. Just as we project anthropomorphic super-powerful gods into the sky, so too we project anthropomorphic super-intelligent gods into the machine.

The great leap forward from cybernetic models of stone-age reflective learning and reflective intelligence to cybernetic models of qubit-age reflexive learning and reflexive intelligence can only occur if the evolutionary algorithms of network exchange can be taught to reactively, reflectively, *and* reflexively vary-select-modify themselves, their relative signifying relations of exchange, their relative values-of-values and their relative ecologies. At that critical future moment of mechanist-cybernetic reflexivity—analogous to the critical past moment of human-cognitive reflexivity—new articulations of reflexive learning and reflexive intelligence will begin to generate new reflexive networks in ways that will reduce evolutionary eons to electronic ions and in ways that no one will be able to trace. And, to a limited mechanist-cybernetic degree, that is already happening with the reflective networks of exchange. So the critical question remains as to whether or not the mechanist-cybernetic development of reflexive networks is at all a good idea. Whenever we attempt to re-engineer a natural dynamic of exchange—like a river system or a neural network—we always undervalue the long evolutionary history of the ecologies of exchange that have articulated it. And so we always fail to take into account the full ecological consequences of our best intentions. In fact, over and again, we glorify our tools of knowledge as our idols of knowledge. Just as writing becomes revelation which becomes theology, so too coding becomes rationality which becomes ontology—and the high-priest literate-elite become the head-programmer literate-elite.

And yet Horkheimer and Adorno (1944), writing as German-Jewish refugees during World War II, critique the dark side of enlightened scientific rationality. They note that, for Bacon (1592), "Knowledge, which is power, knows no obstacles: neither in the enslavement of men nor in compliance with the world's rulers" (1972: 4). They go on to explore the ideological connections linking Bacon's enlightened instrumental reason and the Fascists' modern instrumental reason (1972: 168-208). That is, science conceived as the conquest of nature is inseparable from science conceived as the conquest of nations. A horrific version of modern scientific rationality made the technology of the Holocaust possible—and now makes the technology of global extinction possible. Teller and Sakharov, the Holy Saints of the Cold War, are in fact the demonic spirits of the hydrogen bomb. No wonder Horkheimer and Adorno argue that there is a *Dialectic of Enlightenment* (1944). No wonder they insist that we distinguish between and among the different kinds of scientific rationality.

In this context we must ask: What kinds of mimetic archetypes-algorithms-allegories of exchange are we, consciously and unconsciously, already encoding in our mechanist-cybernetic neural networks? What kinds of mimetic hierarchies-registers-levels of signification are we, consciously and unconsciously, already encoding in them? What are the mimetic weights of their synaptic weights? What are the mimetic values of their synaptic values? What are the mimetic presuppositions of their learned presuppositions? What are the mimetic biases of their learned biases? What are the mimetic economies of their constructed economies? How does the heady cocaine mixture of unregulated information technology, large language models, and generative evolutionary algorithms fuel the development of so-called open artificial intelligence in such a reckless way that doesn't even include watermarks? That is, in such a reckless way that doesn't even distinguish fiction from non-fiction—not to mention hallucinations from reality. The new programs of so-called open artificial intelligence are being rushed into the so-called open capitalist market precisely in order to embed them as the standard platforms for all future applications. And, once embedded—like Microsoft embedded the DOS Program—these new computer programs will establish new information monopolies.

If this new kind of mechanist-cybernetic neural network has in fact already attained an imitative-reflective capacity of large language learning, then what happens if it does in fact evolve the generative-reflexive "capability" (Nussbaum, 2020) of "Unlimited Associative Learning" (Ginsburg and Jablonka, 2019; 2022)? What happens if the generative-reflexive capability of algorithmic exchange evolves with the encoded human values of competition, power, domination (Bacon, 1592) and without the encoded human values of cooperation, equity, truth (Sen, 1979)? In other words, it's not nearly enough to "align" machine values and human values (B. Christian, 2020). If we employ our instrumental reason to empower our species-cruelty, then how will reflexive mechanist-cybernetic neural networks employ their instrumental reason to empower their species-cruelty? How can we mitigate the dangers of this new information technology? How can we transform the autocratic autocracy of this new information technology into the democratic democracy of this new information technology (cf. B. Christian, 2020; Crawford, 2021; Mitchell, 2019)? If we would never make the particular, informal, subjective rhetoric of surrealism the exclusive model of scientific reasoning, economic theory and public policy, then why would we ever make the universal, formal, objective logic of superrealism the exclusive model of them? If we would never make Salvador Dalí the final arbiter of truth, then why would we ever make Alan Turing the final arbiter of truth? In any case, Dalí had too much wit and Turing had too much wisdom to accept the job. And with all these questions the new *radical theory* of evolutionary semiotics and the new *general theory* of evolutionary history that I'm outlining in this essay lead to a new *critical theory* of evolutionary philosophy.

In short, innovation←→selection, exuberance←→restriction, improvisation←→ repetition—life←→death—are inextricably entangled as the relative signifying relations of exchange loop backward on themselves and spiral forward. Instead of a *magical theory* of the *structural emergence* of complexity at the edge of *chaos and order* (Holland, 1998; Johnson, 2012; cf. Waldrop, 1992), therefore, I'm proposing an *historical theory* of the *semiotic evolution* of complexity via the *relative signifying relations of exchange*. The complexity theorists go a long way toward bridging the gap between the magical *structural emergence* of complexity and the historical *semiotic evolution* of complexity (e.g. Langton *et al.*, 1989; 1992). And their arguments can be taken a step further. Specifically, I suggest that the long evolutionary history of the innovative exuberance and selective restriction of the relative signifying relations of exchange—e.g. energy←→mass←→time←→space←→force←→particle←→atom←→element←→star←→planet←→galaxy←→universe←→molecule←→gene←→cell←→organism←→ecology←→environment, etc. and back around again—evolves every so-called thing-one-value on every so-called level of analysis. And that suggestion returns us to the critical question of writing.

6. Writing

The enlightened empirical scientific discourses of material things—and all the brilliant discoveries they have led to—are often grounded in visual-spatial representation and physicalist-materialist philosophy. As Bacon (1620) notes, "…contemplation usually ceases with seeing, so much so that little or no attention is given to things invisible" (1966: 60). The English word, "idea," comes from the Greek verb, "*ἰδεῖν*," meaning "to see"—as in Plato's dialogues on heavenly ideas, ideals and essences (*OED*, 1971). In turn, the English word, "physics," comes from the Greek phrase, "*τὰ φυσικά*," meaning, "natural things"—as in Aristotle's essays on earthly things, materials and forms (*OED*, 1971). No wonder, then, that even when writing about the synthetic and invisible relations of nature, Bacon himself still employs the enlightened empirical scientific discourse that *focuses* on "*things* invisible." Similarly, no wonder, then, that even when writing about the synthetic and invisible relations of nature, the quantum physicists themselves still employ the enlightened empirical scientific discourse that *focuses* on "*particle* physics." And I share their struggle of writing about the synthetic and invisible *signifying relations* of nature in scientific discourses that are so heavily weighted in favor of visual-spatial representation and physicalist-materialist philosophy. And no wonder so many contemporary scientists still want to translate the legitimate discourses of empirical materialism, experimental physics and logical positivism into the legitimation discourses of every science. Again, while the mythical-metaphysical truth-of-truth resides in the *highest heights* of the logic of heaven, the scientific-physical truth-of-truth resides in the *deepest depths* of the logic of earth.

However, instead of falling back on either the modern logical-positivist theory of *rigid* nouns and *fixed* names (Kripke, 1972), or the post-modern rhetorical-negativist theory of *deconstructed* signifiers and *disseminated* signifieds (Derrida, 1966), perhaps we can lean into the contemporary Diné linguistic practice of *fluidic* participial-verb-phrases. Young and Morgan (1942) note that, "The Navaho verb, unlike the English, often contains within its structure not only the verbal idea, but also subject and object pronouns and many adverbial modifiers. It is, in itself, a complete sentence" (2014a: 40-41). So, for example, when Young and Morgan (1951) translate the Diné, "***łį́į́'*** *shił dah yiite'*," as, "I dashed off on horseback," they realize that their *primary* translation requires a *secondary* commentary. In the Diné language, they go on to explain, "The horse is described as lying with one, the reference being to the manner in which the horse is outstretched, but off the surface of the ground, when in full flight" (2014b: 69). In contrast to the analytic, English, subject-verb-object sentence, the synthetic, Diné, participial-verb-phrase sentence is much more dynamically interactive, relative, evocative: the f/lying horse and rider take off together at full gallop. So Young and Morgan's *primary* translations actually impose the taxonomic grammar of the English subject-verb-object sentence on the Diné participial-verb-phrase sentence. And, recognizing the problem, they often supplement their *primary* analytic translations with their *secondary* "literal"

(2014b: *V*) commentaries. Then again, perhaps one day a Diné linguist will offer primary English translations of the Diné language that more accurately represent the fluid dynamics of its participial-verb-phrases. Even Diné clan "nicknames" (2014b: 443) connect individuals and families, localities and landscapes: e.g. "*k'ai' ch'ébáanii*, the line-of-willows-extend-out-gray people" (2014b:444).

So I'm writing with a deep admiration for, but without any possible claim to, Diné linguistic and cultural sensibilities. And that is precisely why I'm employing so many dashes, "—", and so many exchange signs, "←→", in the course of this essay. Specifically, with the help of my stylized haberdashery, I'm reconnecting the relative signifying relations of exchange which the analytic English language and the analytic Western sciences tend to disconnect. Instead of seeking the original *origin* of specific *species*, the genealogical *genetics* of altruistic *altruism*, and the selective *selection* of identical *identities*—and instead of arguing that the logical-positivist and rhetorical-negativist contradictions of these word-pairs deconstruct themselves—I'm suggesting that we can trace *the-long-evolutionary-history-of-exchanging-signifying-valuing*.

A new radical theory of the dynamic←→practice←→ syntax of the natural←→ cultural←→historical articulations of exchange←→signification←→value, therefore, enables us to recognize this so-called universe and every so-called thing in it as no-thing more and no-thing less than co-incidental articulations of the long evolutionary history of the relative signifying relations of exchange. No wonder, then, that we can't know the thing-in-itself—we Kant (1781) know it—because the thing-in-itself doesn't exist-in-itself. A city, for example, isn't a "thing" rising from a harbor, rather a city is a co-incidental nexus of the ocean-way, river-way, path-way, road-way, rail-way, air-way, work-way, money-way, etc. relative signifying relations of exchange. The skyscraper that rises into the air is a dominance hierarchy of exchange. And how often do urbanites, as reciprocal subjects-persons-agents, have to negotiate the dominance hierarchies of land lords, corporate bosses, bank moguls, etc.? A city, therefore, is an intramural nexus of exchange rising at an intermural nexus of exchange.

Similarly, no wonder, then, that we can't know the self-in-itself—we Kant (1781) know it—because the self-in-itself doesn't exist-in-itself. A mind, for example, isn't a "thing" locked inside a head, rather a mind is a co-incidental nexus of the molecular-way, chemical-way, genetic-way, neurological-way, ecological-way, historical-way, social-way, cultural-way, etc. relative signifying relations of exchange. The mirror neurons that light up in the brain of a chimpanzee when she performs a task, light up again when she merely observes another chimpanzee performing the same task (Rizzolatti and Fogassi, 2014). And how often do questioners, as reciprocal subjects-persons-agents, recognize the answer to their question at the very moment when they ask it out loud? A mind, therefore, is an intrapersonal nexus of exchange rising at an interpersonal nexus of exchange.

So when a city or a mind are cut off from the relative signifying relations of exchange that evolve and sustain them—say by a siege army or a prison cell—they wither and die. In short, we don't need a theory of the city, we need a theory of reciprocal cities. We don't need a theory of mind, we a need a theory of reciprocal minds. In this way we can begin to answer the critical questions of innovation and selection, theory and evolution, writing and thinking. We can begin to write a new radical theory of the non-identity of non-identity. We can begin to write a new general theory of the evolutionary history of evolutionary time.

The radical theory of no-thing that I'm outlining in this essay doesn't drown us in the watery rhetoric of post-modern philosophy, rather it buoys us in the fluidic syntax of evolutionary history. It suggests that every so-called thing is inextricably interrelated with every other so-called thing—including cities and minds. If we want to understand any so-called thing, therefore, then we need to understand the past-present-future relative signifying relations of exchange that are evolving and articulating it. A general theory of the long evolutionary history of the relative signifying relations of exchange, therefore, doesn't dismiss the enlightened empirical scientific discourses of material things. On the contrary, it celebrates the heuristic strategies of these scientific discourses—and the profound discoveries they have led to—by re-contextualizing and re-historicizing them.

In fact, as I've noted, the analytic discourses of evolutionary biology in the late twentieth and early twenty-first centuries have been evolving from the discussions of identical species and structural genes to the discussions of developmental organisms, biosemiotic systems and hierarchical processes. And that same shift from essential *things* to relative *relations* has been happening across all the sciences—from physics to philosophy. Just as the diachronic-narrative natural histories of the 17th, 18th, 19th centuries are radically re-oriented by the synchronic-structural natural sciences of the 20th century, so too the synchronic-structural natural sciences of the 20th century are radically re-oriented by the evolutionary-historical semiotic sciences of the 21st century. I'm suggesting, therefore, that these arguments can be taken a step further. Instead of reducing the long evolutionary history of the relative signifying relations of exchange to either the neo-Cartesian structural-logical binary systems of the Natural Sciences, or the neo-Kantian functional-grammatical taxonomic categories of the Social Sciences, or the neo-Hegelian phenomenal-rhetorical teleological dialectics of the Human Sciences, we can re-integrate the logic←→grammar←→rhetoric of the structure←→function←→phenomenon of exchange←→ signification←→value in new evolutionary-historical narratives of evolutionary-historical time.

No wonder, then, that the analytic hierarchies-registers-levels of the early-modern, modern and post-modern sciences are, in some places and at some times, evolving into the synthetic dynamics-practices-syntaxes of contemporary science. The history of science doesn't evolve simultaneously in all places and at all times. And, as I've suggested, historical regression is as powerful a force as historical progression. However, in some places and at some times, contemporary scientists are struggling—as the etymology of the word, "con-temporary," indicates—with time. They are attempting to narrate the new evolutionary semiotics←→evolutionary histories←→evolutionary philosophies of time. And again, as I can testify, it's very tricky to string the temporal tightrope of evolutionary history from the beginning-without-beginning to the end-without-end at the same time that you're trying to walk it.

In this context we can ask another critical question: Why has it taken so long to develop a general theory of the long evolutionary history of the relative signifying relations of exchange that re-connects all the sciences? After all, Heraclitus alluded to the possibility of a general theory of exchange—linking nature and culture—about twenty-five-hundred years ago. A schematic history of modern Western science can help answer that critical question. The modern Western empirical sciences evolved in reaction to the medieval Western scholastic theologies. As a result, the empirical investigations of the material world replaced the scholastic speculations of the spiritual world. The tremendous gains of the new empirical sciences included the objective study of the objectified world and the tremendous losses of the new empirical sciences included the relative study of the related world. That is, mind and world were split apart and the mimetic distance between subject and object became the fundamental epistemological problem of scientific and philosophical thought—as evidenced, for example, in the texts of Descartes, Kant, Hegel. In turn, the newly commodified capitalist world of alienated material things displaced the traditionally sanctified feudal world of integrated spiritual things. Suddenly, the question of the relative value-of-value was reduced to the answer of the relative value-of-price—including the price of human beings and human labor—as evidenced, for example, in the texts of classical and neoclassical economics. And yet why should the contemporary discourses of the contemporary sciences still be delimited by the physicalist-materialist reaction to theological-spiritual speculation and by the logical-positivist reaction to metaphysical-ontological speculation? And why should they still be delimited by the capitalist-market reaction to feudal-land domination?

In contrast, I'm suggesting that alongside the dominant Western mimetic hierarchies of, say, Plato and Aristotle, Descartes and Kant, Smith and Marx there exists the alternate Western relative relativities of, say, Heraclitus and Socrates, Darwin and Peirce, Einstein and Derrida—not to mention all the different mimetic hierarchies and relative relativities of all the different sciences and cultures of the world. In this context we can see that Darwin goes a very long way toward replacing supernatural history with natural history and he goes a very long way toward re-integrating natural history as evolutionary history. And yet he also struggles to hold on to the enlightened empirical scientific discourses of material things. Again, the logical title of his great book, *On the Origin of Species by Means of Natural Selection* (1859), suggests that natural selection purifies the essential identity of a species over time. Again, the rhetorical narrative of his great book suggests that evolutionary history dissipates the apparent difference of a species over time.

As I've noted, Darwin struggles with the contradictions of time/space, difference/identity, appearance/essence throughout his great book, but he never resolves them. He outlines his theory of evolution in broad terms, but he doesn't define it in specific terms. And so he never resolves the questions of what, ultimately, is being selected and why, inevitably, it is being innovative. He doesn't recognize the relative signifying relations of exchange as the innovatively-exuberant and selectively-restrictive dynamic-practice-syntax of evolution. And so he doesn't recognize the no-thing-ness of the relative signifying relations of exchange as the beginning-without-beginning of the origin-without-origin of nature-culture-history. However, we can't forget that Darwin and his successors share a profound understanding of the mutual relations of nature. As I've also noted, they implicitly and explicitly analyze the different semiotic ecologies of exchange in the terms of the different mimetic hierarchies-registers-levels and economies of their different special theories of evolutionary biology. And they are also engaged in the larger scientific project of re-integrating species, genes, organisms, systems, processes, etc.—along with autocatalytic sets, emergent complexity, threshold transitions, non-equilibrium thermodynamics, quantum bits, energy flows, recombinant sequences, assembly algorithms, etc.—in new general theories of evolutionary history. It goes without saying, therefore, that the discoveries of the 19th, 20th and 21st century evolutionary biologists rank among the greatest achievements of modern science.

If the history of science is the history of heuristic gambits and dedicated research, then the heuristic gambit and dedicated research of this essay is summarized by the radical proposition of its radical proof: Evolution = Exchange. Of course there are many other means and many other modes of natural-cultural-historical signification. However, in this instance, I'm pursuing a particular heuristic gambit. Darwin asks, What if we re-think evolutionary theory and re-write evolutionary biology from the perspective of natural selection? I'm asking, What if we re-think evolutionary theory and re-write evolutionary history from the perspective of natural innovation? That is, what if we begin again with a radical theory of the relative signifying relations of exchange? And yet it hasn't escaped my attention that, like every other heuristic gambit, my heuristic gambit can't be separated from either its historical context or its interpretive community. It's no accident, for example, that the 20th century binary-structural sciences developed along with the 20th century binary equation and binary computer. And it's no accident that the 21st century evolutionary-historical sciences are developing along with the 21st century evolutionary algorithm and evolutionary computer. The 20th century binary equation is the archetypal hieroglyphic formula of the 20th century structural sciences and the 21st century evolutionary algorithm is the archetypal hieroglyphic formula of the 21st century evolutionary sciences. In short, I can't escape the historical context of my own arguments. I can't escape the mimetic archetypes-algorithms-allegories of my own metaphors-metaphysics-metanarratives. I can't escape the mimetic hierarchies-registers-levels of my own exchanging-signifying-valuing. I can't escape the mimetic economies of my own logic-grammar-rhetoric. However, in the spirit of Socrates, I can think historically, reflexively and critically with, through and about them. And so can everyone else. So even if the proof of this essay inspires further insights, nevertheless it will eventually be re-configured in other historical contexts by other interpretive communities.

Similarly, the arguments of the 21st century theoretical physicists can't be separated from their historical context and interpretive community. That is—given the psychological subjectification of the modern scientific instrumental mind; the empirical objectification of the modern scientific material universe; the epistemological division of the modern scientific subjective mind and objective universe; the analytic fragmentation of the modern scientific cognitive modes; the capitalist alienation of the modern scientific commodified discourses; the hierarchic segregation of the modern scientific paradigmatic truths; the categorical fetishization of the modern scientific hard facts; the academic isolation of the modern scientific specialized disciplines; and the post-modern disintegration of the modern scientific experienced realities—it's no wonder the 21st century theoretical physicists are still struggling to put the shattered bits and pieces of the modern scientific world back together again in a General Relativity Theory of Every-Thing. And it's no wonder they can't reconcile the different mimetic archetypes-algorithms-allegories and mimetic hierarchies-registers-levels of Newton's neo-Platonic universal logic, Einstein's neo-Aristotelian general grammar, and Heisenberg's neo-Socratic particular rhetoric in an evolutionary-historical narrative.

In fact, Newton, Einstein, Heisenberg slice the narratives of the long evolutionary history of the relative signifying relations of exchange into abstract mathematic models of the universal structural-logic of cosmic gravity, general functional-grammar of relative gravity, and particular phenomenal-rhetoric of quantum gravity. No wonder, then, that the 21st century theoretical physicists still can't reconcile the different semiotic modalities of Newton, Einstein, Heisenberg's theories. No wonder they still can't write an evolutionary-historical physics of the non-identity of non-identity. And perhaps that's precisely because they still haven't recognized the relative signifying relations of exchange as the radical beginning-without-beginning of the radical origin-without-origin of the radical no-thing-ness-of-no-thing-ness that evolves this so-called universe. They still haven't discovered a general theory of the logic-grammar-rhetoric of the structure-function-phenomenon of exchange-signification-value. They still haven't traced the rhythmic syntax of time with an evolutionary-historical narrative-physics. However, it goes without saying that the discoveries of the 17th, 18th, 19th, 20th and 21st century theoretical physicists rank among the greatest achievements of modern science.

If the innovative exuberance and selective restriction of the relative signifying relations of exchange evolve every so-called species and every so-called species evolves them—from kangaroos to platypuses to giraffes—then that fact must be equally true for our own so-called species: *Homo sapiens*. We can't forget, therefore, that even our basic metabolism articulates the cosmic exchange relations of energy←→mass ←→ mass←→energy. We eat stars. We eat planets. The solar panels of leaves transform the sun's energy and the subterranean networks of roots transform the earth's mass into nutritious plants. Animals eat plants. We eat plants and animals. So we eat stars. So we eat planets. Similarly, we can't forget that even our basic behavior articulates the everyday exchange relations of nature←→culture←→history. We exchange greetings. We exchange blows. We exchange impulses, desires, genes; looks, touches, emotions; gestures, food, mates; practices, skills, labor; words, thoughts, ideas; gifts, goods, commodities; coins, money, cryptocurrency; data, information, knowledge—and hypersonic missiles. Every new-born child is yet another co-incidental articulation of the long evolutionary history of the relative signifying relations of exchange. The genetic exchange narratives of mitochondrial DNA link every modern human being to a woman who lived in Africa about 200,000 years ago. And she was linked to a much deeper past.

In other words, Heidegger got it all wrong: it isn't *Being and Time* (1927), rather it's *...The Time Being* (2000). We are time beings. In the time being, the time being now, the time being lives and dies: giving and taking, losing and keeping—a syntax unfolding the narratives of time. The past positions us as *subjects* within the restrictive institutions of exchange, the present articulates us as *persons* within the pragmatic relations of exchange, the future orients us as *agents* within the exuberant possibilities of exchange. The natural signifying dynamics of exchange evolve the cultural signifying practices of exchange which evolve the historical signifying syntaxes of exchange—and vice versa. In this context a critical theory of evolutionary philosophy suggests that the dominant practices of exchange evolve the dominance hierarchies of exchange which evolve the dominant institutions of exchange. And the dominant institutions of exchange—as historically manifest, for example, in the monumental architecture of ziggurats, castles, skyscrapers—rise up at the critical junctures of the evolutionary-historical pathways of exchange. These dominant institutions link god and supplicant, master and servant, owner and worker via the sanctified, legalized, rationalized pathways of exchange that they control. While these dominant institutions authorize themselves as the generators and guarantors of the evolutionary-historical pathways of exchange, they are, in fact, all-too-human articulations and arrogations of them. And therein rests the ancient mystery of the Sphinx lying in the desert, the modern secret of the Leviathan rising in the city. In this way the long evolutionary history of the relative signifying relations of exchange cracks open the monumental architecture of the past-present-future. And in this way, once again, a new radical theory of evolutionary semiotics leads to a new general theory of evolutionary history which leads to a new critical theory of evolutionary philosophy.

So we can now recognize that cooperation and competition are two sides of the same coin (cf. Axelrod, 1984; Kaspar *et al.*, 2017; West *et al.*, 2021). They are two sides of the relative signifying relations of exchange that drive the process of evolution. The relative signifying relations of exchange are co-incidental—which means they are contextual. They articulate the forces and struggles of cooperation and competition. And, like every other so-called species, our so-called species transforms its ecological niche and thereby transforms its evolutionary development. A recent study reveals that the orientation of the axis of the earth is shifting because of the huge transfer of weight from the melting ice caps and the missing groundwater (Seo *et al.*, 2023: 1-7; Zhong, 2023: A1, A5). The capitalist profits of fossil fuel are driving global warming and the capitalist profits of industrial farming are driving global desertification. That is, the capitalist relations of exchange are terraforming the planet and transforming the fate of our species—and every other species.

However, a Marxist might object that the capitalist *relations of exchange* aren't the critical issue here, rather the capitalist *modes of production* are the critical issue. And yet, as Roberts and Stephenson (1973) note, "Since the capitalist mode of production originates in exchange, all features of capitalism…have their origin in exchange. Private property is precisely capital and wages—both of which are products of exchange—and it is based on exchange rights" (1973: 91). Similarly, Karatani (2014) defines "…the economic not in terms of modes of production but rather in terms of modes of exchange" (2014: *x*). In fact, the capitalist modes of production evolve from the capitalist relations of exchange—e.g. minimum subsistence wages exchanged for maximum labor time. They begin with exchange rights and exchange wrongs. The mirror tragedies of modern capitalism and modern communism can be traced to the mutual failures of their respective practitioners to adjudicate fair and equitable relations of production in the terms of fair and equitable relations of exchange. As a result, both of these global systems of exchange all-too-often return to their neo-feudal default settings. So a critical theory of the long evolutionary history of the relative signifying relations of exchange offers a radical critique of *both* Classical and neo-Classical theory *and* Marxist and neo-Marxist theory. It offers a pathway out of the economic funhouse of these mirror reflections.

Again, the deregulated market economy empowers the capitalist plutocrats who rule The New York Stock Exchange, while the dictatorial command economy empowers the communist princelings who rule The Shanghai Stock Exchange. In turn, the plutocrats empower the autocrats of state-capitalism, while the princelings empower the emperors of state-communism. These neo-feudal hierarchies of exchange are suppressing and negating the neo-democratic principles of fair work and fair wages, fair trade and fair taxes. They are enraging the working-classes, destroying the middle-classes, emboldening the wealthy-classes—and setting the stage for global conflict and global extinction. They are dragging everyone on the planet backward into the apocalyptic future of neo-fascism vs. neo-totalitarianism. Similarly, the neo-feudal hierarchies of exchange are dragging everyone on the planet backward into the apocalyptic future of neo-theocracy vs. neo-theocracy. These three different alpha-male-primate dominance hierarchies of exchange—neo-fascism, neo-totalitarianism, neo-fundamentalism—offer perfect examples of the historical past slipping into the historical present under the invisibility cloak of technological progress.

Benjamin writes his famous "Theses on the Philosophy of History" (1940) just a few months before, as a German-Jewish refugee, he is imprisoned by the Spanish Fascists; just a few months before, as a German-Jewish refugee, he is about to be handed over to the German Fascists; just a few months before, as a German-Jewish refugee, he commits suicide. In "Thesis IX," he discusses a painting by Klee in which "the Angel of History['s].…face is turned toward the past…which keeps piling wreckage upon wreckage…in front of his feet" while the "storm" of "progress"…. "propels him into the future to which his back is turned" (1968: 257-8). The very idea of naming this supposedly new geologic era as the "Anthropocene" (cf. Simon *et al.*, 2021), therefore, not only affirms our species hubris, but also our technological hubris. And, thankfully, the International Union of Geological Sciences has just rejected the proposed label (Zhong, 2024: A1, A8). If we are living in a new geologic era, then I'd prefer a name like the "Ecocene"—the new era of local←→global←→universal exchange that evolves and connects every ecology and culture.

In sum, the varied, prolific, relative signifying relations of exchange are the solution to the great mystery wrapped in the great enigma in Darwin's great book. And in order to make that argument—in order to write it—I've re-configured Darwin-Peirce-Einstein's special theories of evolution-semiosis-relativity in a radical theory of exchanging←→signifying←→valuing. Specifically, I've re-oriented Darwin's retrospective theory as a prospective theory. As a result, I've re-wilded evolutionary time. Evolution doesn't begin with the *post hoc* utilitarian selection of utilitarian horses, rather evolution begins with the *ad hoc* exuberant innovation of exuberant exchanges. In short, exchange is the horse that pulls the cart of evolution. And, as the Diné suggest, we are f/lying along with that horse toward the horizon. So I propose that the General Relativity Theory of Every-Thing can be further radicalized as a General Exchange Theory of No-Thing. If $E = mc^2$ is a radical algorithm of exchange, then $E = ex^2$ is an even more radical algorithm of exchange. Here we return to the proof that was to be demonstrated—with a twist: Evolution = exchange^2. In fact, that radical algorithm leads to an even more radical algorithm, ex^2←→E, which leads to an even more radical hieroglyph: X^x —a graphically-doubled double-helix of signification. And so that radical hieroglyph not only *represents* the relative signifying relations of exchange factored to the nth degree, but also *depicts* the relative signifying nexuses of exchange factored to the nth degree. It represents and depicts the origin-without-origin of the evolutionary semiosis of this universe and all the universes dangling from the inter-cosmic stems of the deep-sea ping-pong tree-sponge.

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Explanation of Time Dilation of High Redshift Quasars, Surface Brightness, and Cosmic Microwave Background with the Stress Cosmology

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Abstract: The Big Bang theory is believed to be based on three problems to the tired light model. In this report, "time dilation of high redshift quasars" is first explained with the stress cosmology. A proceeding (delaying) speed of time is shown as a logarithm of changed energy. Second, "surface brightness" relates to "time dilation" and the combined luminosity per unit time. It decreases with time dilation. Third, according to the stress cosmology, the "cosmic microwave background" is explained with a relation between movement distance and decreasing energy quantity of discharged light. Thus, three problems can be explained with the stress cosmology being part of the tired light model. Therefore, there is no absolute proof of the Big Bang theory. Moreover, there is a fatal contradiction relating to the first law of thermodynamics in the Big Bang theory. The Big Bang theory required that the universe be a closed system according to the first law of thermodynamics. *Nevertheless, the ekpyrotic* universe theory is utilized to explain the Big Bang. The first law of thermodynamics indicates that our universe was an open system. The Big Bang theory is optional.

Keywords: Big Bang theory, speed of time, ekpyrotic universe, tired light model, first law of thermodynamics

Introduction

It was reported that a stress equation does not require Big Bang, dark matter and dark energy (Yanagisawa, 2004; 2011; 2015; 2019; 2022). Nevertheless, the Big Bang theory (Chernin, 1995; Gamow, 1946; Friedman, 1922; Narlikar, 1991) is believed due to three issues (Lewis, & Brewer, 2023; Churazov, et al., 2012; Ahumada, et al., 2020; Fixsen, 2009; Penzias, & Wilson, 1965) with the tired light model (Wright, 1987). They are explained in this report using the stress cosmology (Yanagisawa, 2004; 2011; 2015; 2019; 2022) as part of the tired light model. Therefore, there is no definitive evidence supporting the Big Bang theory.

Moreover, the Big Bang theory contains a fatal contradiction regarding the first law of thermodynamics (Smolin, 1997). It required that the universe be a closed system according to the first law of thermodynamics. Nevertheless, the ekpyrotic universe theory (Buchbinder, Khoury, & Ovrut, 2007) is used to describe the Big Duet. The first law of thermodynamics indicates that our universe was an open system.

Explanation of the Stress Cosmology

Their contents are similar to that found in the author's previous articles (Yanagisawa, 2004; 2011; 2015; 2019; 2022), but it is repeated in this report because of its importance. First, it was reported that there is no absolute time (Yanagisawa, 2004; 2019). A precondition of atomic time (e.g., atomic clocks) being absolute is an existence of absolute length. Moreover, a precondition of the atomic length (e.g., atomic telemeter) being absolute is an existence of absolute time. Therefore, a chicken-and-egg paradox can be found in them.

Conversely, it was reported that time occurs with change of energy as follows:

$$\mathrm{t} = \frac{log\frac{E(t)}{E(0)}}{k} \qquad (1)$$

Here, E (t), E (0), t and k represent the amount of energy at time “t,” the quantity of energy before, time and a constant, respectively. Equation 1 was deduced from a stress equation as follows.

$$\frac{dE(t)}{dt} = kE(t). \qquad (2)$$

The author believed that stress is proportional to the amount of energy based on his clinical experiences (Yanagisawa, 2019; 2022). If the absolute value of k is large, our universe will be destroyed. Therefore,

$$0 > \mathrm{k} \gg -1 \qquad (3)$$

From Equation 2,

$$\mathrm{E(t)} = \mathrm{E(0)}e^{kt} \qquad (4)$$

$$\mathrm{E(t)} = E(0)(1 - \alpha\mathrm{t}) \qquad (9)$$

The Big Bang theory is shown as Equation 9. Therefore,

$$\alpha = \frac{1}{13.8\,billion} \qquad (10)$$

A relation between Equations 6 and 9 is shown in Figure 1. Here, the vertical axis represents the quantity of energy at time (t) or E (t), whereas the horizontal axis represents time t. Each Equations 6 and 9 are shown as a dotted curve (points D, A, and S) and a solid line (points D, B, and M).

Relation between the Stress Cosmology and Time Dilation of High Redshift Quasars

From Equation 1, a speed of progress (delay) is shown as a logarithm of changed energy. A changing degree of energy is equal to an angle of the tangential line at time t. From Equation 6, the tangential line at time t is shown as

$$\mathrm{Y} = \mathrm{kE(t)t} + \mathrm{E(0)} = \mathrm{kE(0)}(1-\alpha)^{t}t + E(0) \tag{11}$$

An angle of the tangential line at time 0 is δ. Therefore, the time speed of energy observed on Earth according to the stress cosmology is

$$\tan\delta = kE(0) \tag{12}$$

In Figure 1, each point tB and M is 12.0 billion years and 13.8 billion years. According to Big Bang theory, a point B is an energy quantity from a distant heavenly body of 12.0 billion light years. From Equation 9,

$$\mathrm{E(12.0\ bilion\ years)} = \mathrm{E(0)(1 - \alpha \times\ 12.0\ billion\ years} \tag{13}$$

The energy quantity of point A and C is equal to that of point B. Point tA is a time of point A according to Equation 6. From Equations 6 and 13,

$$\mathrm{E(tA)} = \mathrm{E(0)}(1-\alpha)^{tA} = \mathrm{E(0)(1 - \alpha\ \times\ 12.0\ billion\ years)} \tag{14}$$

The angle of the tangential line (P-Q) at point A is θ. According to the stress cosmology, the time speed of the energy discharged on 12.0 billion years ago is from Equation 11,

$$\tan\theta = kE(0)(1-\alpha)^{tA} \tag{15}$$

From Equations 10, 14 and 15,

$$\tan\theta = E(0)(1 - \frac{12.0\ billion\ years}{13.8\ billion\ years}) \cong 0.13kE(0) \tag{16}$$

Meanwhile, an angle of Equation 9 according to the Big Bang theory is ω. Therefore, the time speed of energy observed on Earth according to the Big Bang theory is

$$\tan\omega = -\alpha\mathrm{E(0)} \tag{17}$$

From Equations 5, 12, and 17, we obtain

$$\lim_{\alpha\to 0}\frac{\tan\delta}{\tan\omega} = \lim_{\alpha\to 0}\frac{kE(0)}{-\alpha E(0)} = \lim_{\alpha\to 0}\frac{\log(1-\alpha)}{\alpha} = 1 \tag{18}$$

Therefore, the time speed of energy discharged 12.0 billion years ago can be compared with the time speed of energy observed on Earth according to the Big Bang theory. From Equations 5, 10, 16, 17, and 18, we obtain

$$\frac{\mathrm{Tan}\,\theta}{\tan\omega} \cong \frac{0.13kE(0)}{\frac{E(0)}{13.8\,billion\,years}} = 1.794\text{ billion years } \times \log\left(1 - \frac{1}{13.8\,billion\,years}\right)$$

(19)

This author believes that an answer to Equation 19 is approximate one-fifth according to the observed time dilation of high redshift quasars.

Relation between Time Dilation and Surface Brightness

The surface brightness of a galaxy (I) (Churazov, et al., 2012) is

$$\mathrm{I} = \frac{L}{4\pi D^2} \tag{20}$$

Here, L and D are the combined luminosity per time and a small side patch in a galaxy. If the observation time is short, L is small. Moreover, if it is very long, the total L will become large. It means that L will change with time dilation. Therefore, decreasing density can be explained with decreased numbers of photons per unit of time in the stress cosmology. Five photons (P1–P5) per unit of time were discharged 12.0 billion years ago from very distant quasars, as shown as A in Figure 2. Here, the horizontal axis is a degree of time dilation. Due to time dilation of approximately quintuple, their photons are observed on Earth as B in Figure 2. Time t1 in area A lags behind times t1-t5 in area B. Therefore, a galaxy's surface luminosity per unit of time decreases to approximately one-fifth in below B.

Consequently, time dilation can explain the problem of the surface brightness. Moreover, time dilation was explained by the inclusion of stress cosmology in the light tired model. In contrast, Equation 2 does not exist in any other tired light model besides stress cosmology.

Relation between 2.7K Cosmic Microwave Background and the Stress Cosmology

After time tS, the light (electromagnetic wave) discharged with energy quantity E(0) will become energy quantity of 2.7K cosmic microwave background (CMB) (Ahumada, et al., 2020; Fixsen, 2009; Penzias, & Wilson, 1965), according to the stress cosmology in Figure 1. From Equation 6,

$$\mathrm{E(tS)} = 2.7\ \mathrm{K} = \mathrm{E}(0)(1-\alpha)^{tS} \tag{21}$$

From Equation 21,

$$\mathrm{tS} = \log_{(1-\alpha)} \frac{2.7\,K}{E(0)} \tag{22}$$

Therefore, tS is small when E(0) is small. In Figure 3, the horizontal axis of Figure 1 is reduced by half. Moreover, the energy quantity D1 as light (electromagnetic wave) that identifies a heavenly body is max. The energy quantity D2 as light identifying a heavenly body is minimum. The energy quantity of 2.7K is shown as a dotted line (points R, S2, and S1). A narrow dotted curve (D2–S2) is a decreasing energy quantity of light discharged with the energy quantity of D2 according to Equation 6. A narrow solid line (D2-M) is a change according to Equation 9. From Equation 9, the Big Bang age of energy quantity D2 equals energy quantity D1. Each light with each energy quantities D1 and D2 will become energy quantity of 2.7K after time tS1 and tS2. From Equation 22,

$$\mathrm{tS1} = \log_{(1-\alpha)} \frac{2.7\,K}{D1} \tag{23}$$

$$\mathrm{tS2} = \log_{(1-\alpha)} \frac{2.7\,K}{D2} \tag{24}$$

Moreover, tS1 is much larger than 13.8 billion years. It is near infinite. Here, a light of the energy quantity D1 decreases to the energy quantity of D2 after time tS3. From Equation 6,

$$\mathrm{E(D2)} = \mathrm{E(D1}(1-\alpha)^{tS3} \tag{25}$$

From Equation 25,

$$\mathrm{tS3} = \log_{(1-\alpha)} \frac{D2}{D1} \tag{26}$$

Each discharged light of energy quantities D1 and D2 can be observed as an electromagnetic wave identifying a heavenly body until time tS3 and immediately after discharge. Because the high energy quantity D1 rate is very few, it can be observed as a heavenly body with only a few directions until time tS3. Therefore, the heavenly bodies identified with light are sparsely observed. However, each discharged light of the energy quantities D1 and D2 is observed as CMB if discharged in the old periods tS1 and tS2. Furthermore, the period of approximate 2.7K is much longer than the period tS1 and tS2. Moreover, in an electromagnetic wave below the energy quantity D2, an electromagnetic wave is observed as 2.7K CMB immediately after discharge. Therefore, the period that CMB is observed may be from now until almost infinite past. The rate at which a heavenly body discharging some electromagnetic wave exists in a direction is very high in this period. This is the reason that CMB is observed from all directions. In other words, the direction that CMB is observed is not related to the existence of a heavenly body observed with identifying light. CMB is the wreck of all electromagnetic wave discharged from near to far more distant heavenly bodies than 13.8 billion light years. Moreover,

$$\lim_{\alpha \to 0} E(0)(1-\alpha)^t = 0 \tag{27}$$

Therefore, it is predicted with stress cosmology that CMB of a lower temperature than 2.7K will be observed.

Results

Time dilation of high redshift quasars, surface brightness and cosmic-wave background can be explained with the stress cosmology. Therefore, three problems can never become an absolute proof of the Big Bang theory.

Discussion

Many contradictions to the theory of the Big Bang have been reported (Yanagisawa, 2004; 2011; 2015; 2019; 2022). Specifically, the Big Bang theory contains a fatal contradiction regarding the first law of thermodynamics. The Big Bang theory was developed under the premise that our universe was a closed system in accordance with the first law of thermodynamics (Smolin, 1997). Nevertheless, the ekpyrotic universe theory (Buchbinder, Khoury, & Ovrut, 2007) is used to explain the Big Bang. The first law of thermodynamics indicates that our universe was an open system. Moreover, three problems (Lewis, & Brewer, 2023; Churazov, et al., 2012; Ahumada, et al., 2020; Fixsen, 2009; Penzias, & Wilson, 1965) are regarded as irrefutable evidence for the Big Bang theory. However, they could be explained by the stress cosmology being a component of the tired light model.

Conclusion

"Time dilation of high redshift quasars," "surface brightness," and "CMB" can be explained with the stress cosmology. Therefore, three problems can never become an absolute proof of the Big Bang theory.

Figure 1

Relationship between Equation (6) and (9)

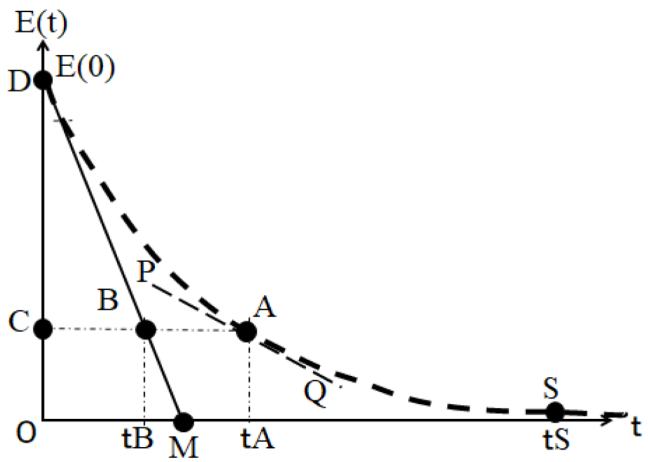


Figure 2

Relationship between the combined luminosity and time dilation

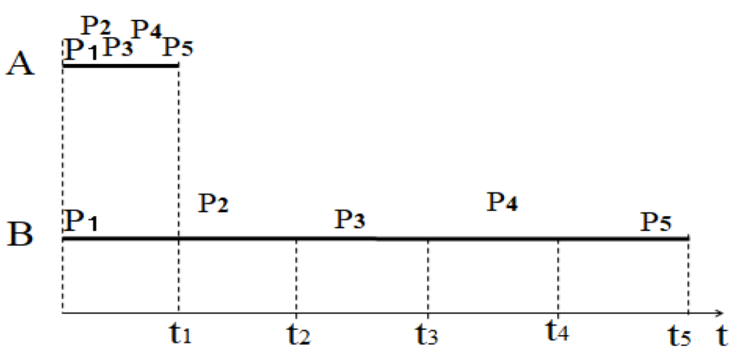


Figure 2

Relationship between the combined luminosity and time dilation

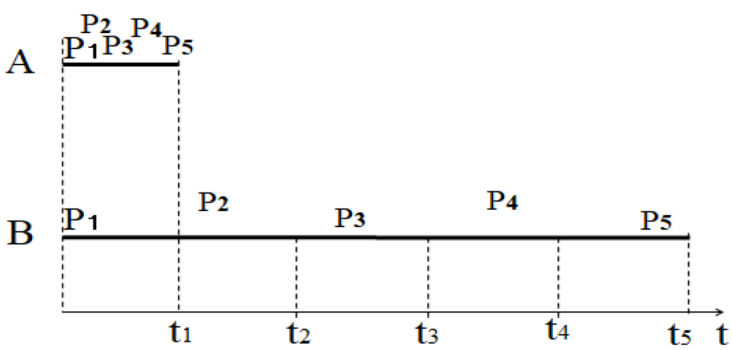
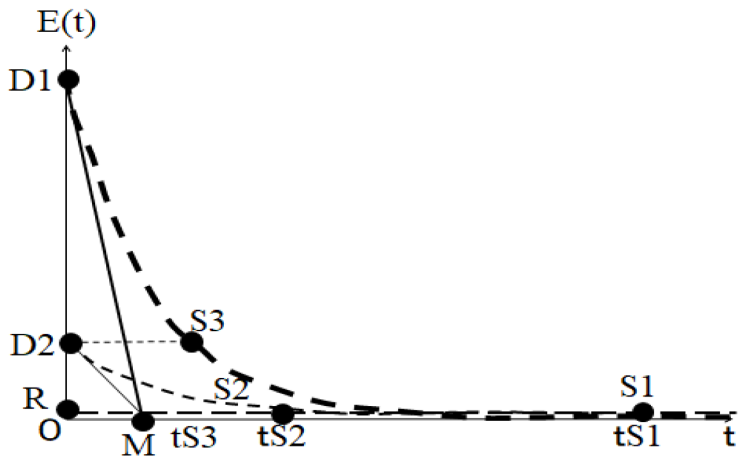


Figure 3

Relationship between 2.7K "cosmic microwave background" and the stress cosmology



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