Complexity: A Rationale for the University

Lowell Gustafson
Villanova University

Correspondence | **Lowell Gustafson** lowellgustafson@gmail.com
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Abstract: Complexity provides a unifying theme that responds to fundamental questions about the emergent structure of the universe as well as human nature. It offers an intellectual framework for disciplines throughout universities. It structures a universe of knowledge across natural sciences, social sciences, and the humanities – from quarks to global societies and human fascination with inter-galactic relations. Ideas of complexity begin with its unidirectional emergence from the big bang to us now. The idea is developed by its multidirectional emergence that includes narratives from the big bang to planets, galaxies, and life forms other than our own. Furthermore, complexity often entails stasis, with levels of complexity remaining as they are, reversing to simpler levels, or all or parts of nature ending altogether. Speculations about multiple universes lead to an idea of infinite complexity.

1. Introduction

The topic of complexity draws on a universe of knowledge and presents an intellectual rationale for the contemporary university. The topic, like the contemporary university, is predictably complex. Universities house multiple schools, colleges, departments, centers, and other administrative units. Unifying key evidence from each of its disciplines to substantiate an account of a universe of knowledge provides an intellectual rationale rather than just the administrative organization of a university. Complexity is one theme that lends itself to that rationale. It includes the ideas of unidirectional and multidirectional emergence, statis, devolution, and infinity.

Emergent complexity responds to age-old fundamental questions. "Like our ancestors, we look up at the heavens and wonder. What is the structure of the universe? How significant are we? Are we alone?" (Library of Congress, n.d.) How did we get here? What does that mean for who we are now and what we can reasonably expect in the future? Complexity is one theme that permits all the disciplines within universities to contribute to a coherent set of responses to such questions.

Disciplines from the natural sciences, social sciences, and humanities contribute evidence towards a substantiated account of development from quarks, protons and neutrons, atoms with 1 or 2 protons and electrons, stars and galaxies, atoms with more than 2 protons, chemicals, second and third generation stars, terrestrial planets like Earth, the origin and increasing complexity of life forms, one of these forms being hominins and then humans, and increasingly complex relationships among humans in kinship groups, villages, cities, nations and empires, and global systems. Humans, each with a hundred billion neurons and maybe a trillion synapses, now number some 8 billion, with more humans connected digitally to each other than ever before. And throughout the human experience, our species has looked to the skies and wondered what our place is in the cosmos.

Emergent complexity does not only go from the big bang to humans, although it does do that as well. Rather, it is multidirectional. It leads to different types of stars, galaxies, planets, and life forms. The known life forms are still those on Earth, but astrobiology suggests that they may well be evolving elsewhere as well.

Also, complexity does not always continue to emerge. Those units within each new stage of complexity often remain in stasis; they do not become more complex. Additionally, complexity includes reversal as well as emergence and stasis.

What complexity has existed often breaks down into simpler levels. The emergence to increasingly simple levels of complexity eventually leads to endings or death. There is informed speculation at the universal level about this leading to rebirth or a new cycles, as well as about the greatest complexity being an infinite number of types of universes.

2. The University, the Universe, and Unidirectional Emergence

Unidirectional emergent complexity, the traditional big history account, which leads us from the big bang to humanity, offers an important rationale for contemporary universities. The International Big History Association defines the field of big history like this: “Big History seeks to understand the integrated history of the Cosmos, Earth, Life, and Humanity, using the best available empirical evidence and scholarly methods.” Some major sources on big history include books, presentations, and textbooks (Stokes-Brown, 2007; Chaisson, 2006; Christian, 2004, 2008, 2010, 2011, 2015; Christian, Stokes-Brown, Benjamin, 2014; and Spier, 2015).

Contemporary universities very often cover portions of this account in their departments and disciplines. Evidence about the cosmos is especially included in physics and astronomy. Material from chemistry is included in all four areas. Geology and geography are especially important in the history of the Earth. Biology is central to the discussion of life’s origin and evolution. Physical anthropology presents the origins and evolution of hominins to humans. Once we get to human studies, the range of social sciences, humanities, law, nursing, medical, business, and engineering provide material about collective learning that big historians examine. The many departments and colleges within universities have been able to provide so much important knowledge because of their disciplined foci. This often comes at the expense of synthesizing knowledge from different disciplines. The tremendous work that has been done within disciplines has overwhelmed universities’ attempts to provide an intellectual rationale for themselves within a universe of knowledge. Directionless programs in “General Studies” rarely make an effort to synthesize knowledge. Universities rarely seek to succinctly offer students a single course or major which value synthesis of all disciplines. Expertise and intellectual skills from the dissection of knowledge are the best many have to offer.

Universities have sometimes come to operate as holding companies for a variety of colleges. A college is often a holding company for a variety of disciplines. Even disciplines are sometimes uneasy collections of sub-fields without clearly stated definitions. Specialization and expertise are often seen as the key intellectual virtues and the only justification for research support. Hiring, prestige, tenure, and promotion are generally tied to recognition by disciplinary programs and journals. College and university administrators struggle to meet budgets, allocate available funds and hiring lines to departments and colleges, and generally keep the trains running on time. Deans and provosts do not always have the luxury to reflect on intellectual mission.

The study of unidirectional emergent complexity seeks to overcome this difficulty and provide an intellectual rationale – a complex universe of knowledge – to which all disciplines of the university contribute. Each part of this account has been made possible only through disciplinary focus. The account as a whole would be possible through the synthesis of each of these parts all within a university; this needs to be done within a course or a series of courses far more often than it is.

3. Disciplines and Unidirectional Emergent Complexity

3.1 Physics and Astrophysics

3.1.1 Big Bang

The beginning of our story is the big bang of 13.82 billion years ago, sometimes thought to have emerged from an infinitely hot and dense point without mass, or nothing (Sing, 2004). Or not. It may be that nothing is really something; it is always pulsating and foaming and regularly turning into a variety of forms of something. Perhaps we live in a popcorn multiverse with an infinite number of big bangs going off all the time in ways we cannot detect or imagine (Greene, 2011). Other universes with different fundamental laws and forces may be sharing our space or off in other locales. Or maybe our own yo-yo universe has an infinite set of cycles of trillions of years (Steinhardt, 2007).

We used to think there was only one galaxy, that the Milky Way was the universe with a few clouds of something or nebulae circling around it. Then we wondered if there were other inhabitable planets. We now know there are great numbers of both, many or most of which we cannot currently see as they are now. Why should ours be the only universe? However, for now we will prosaically restrict our attention to our own universe.

The extraordinarily hot and dense radiation and plasma immediately after the big bang was dramatic. A second after the big bang, the temperature is said to have been 10^{32} Kelvin degrees, or 18 billion degrees Fahrenheit (Hooper, 2019). It was as largely as uniform a situation as has existed in our universe's history.

All but immediately after our own universe's big bang, when energy first congealed into normal or baryonic matter, six types of quarks appeared. They can appear again if protons and neutrons are smashed into each other at sufficient energy levels, which is done rather routinely at Fermilab and CERN. Four of these quarks lead extraordinarily brief lives before returning to energy; they do not go on to form more complex forms of matter. However, two of them – the up and down quarks – did form relationships as they appeared. This will be a pattern. Some things go on to participate in emergent complexity. Many do not.

For a billion and one bits of matter that appeared, a billion bits of anti-matter did as well. "Antimatter particles share the same mass as their matter counterparts, but qualities such as electric charge are opposite. The positively charged positron, for example, is the antiparticle to the negatively charged electron" (CERN,n.d.). Rather than playing well together, matter and anti-matter annihilate each other. This mayhem is a rather good thing from our point of view, since if all the matter that appeared survived, the universe would have been just too crowded to ever have developed into us. And plenty remained. Enough matter to eventually make a hundred billion galaxies each with an average of a hundred billion stars all have been formed by the leftovers of the great annihilation. Those quarks that survived formed relationships that have lasted billions of years. Destruction can be very creative.

The lucky surviving quarks did not exist in isolation; they formed pairs or threesomes. Their relationship is structured by the strong force that is mediated by the exchange of the charmingly named gluons. Two quark pairs are mesons (often very short-lived); threesomes are often very long-lived baryons, whether protons or neutrons. Two up quarks and a down one form a positively charged proton; two downs and an up form a neutron. All that were formed were single or double protons, what would become later the nuclei of hydrogen and helium with a very small smattering of deuterium and others. It was too hot and dense for protons to form relationships with electrons, so there were no atoms yet.

Why is the strong force exactly as strong as it is and not weaker or stronger? Is it different in other universes? Who knows? It is just the way we do things in our universe. But if it differed at all, we would not be here and neither would anything else that we know of.

The quarks do not merge into one undifferentiated blob. Each proton and neutron is constituted by two different types of quarks. Relationship includes individuality. The one and the many exist together. The quarks relate to each to other through the strong force, but they keep their distance as well. Relative to their own size, quarks have a rather pronounced need for personal space. Each of these three move in a constant dance around the others. They are always related, always moving, always distinct. Nature at rest is hard to find. Nature is spinning, moving, and restless.

The protons and neutrons that were formed quickly after the big bang are with us still after almost 14 billion years. In fact, they are us, and everything else that we can see or feel. The structured relationships among individual quarks have been remarkably sustained. There are a lot of them that make each of us. As inventive and creative as nature is, it also keeps certain things around for a long time. And as we will see, lots of very new and more complex types of relationships keep forming. If liberalism is about change and conservatism about keeping things the way they are, we can answer an interesting question. Something came from nothing (or something else) at the big bang. That is change. Quarks can maintain their relationships for tens of billions of years. Can't get much more of a status quo than that. So is the universe liberal or conservative? And the answer is – yes.

About three hundred and eighty thousand years after the big bang, when the universe had expanded enough to cool to around 3000 degrees Kelvin, the electromagnetic force mediated by the exchange of photons could structure a sustained relationship between protons and electrons. Atoms appeared. Hydrogen, with one proton and one electron, appeared in the greatest numbers. If you add up their mass, about three quarters of all atoms in the universe are still hydrogen. If you count atoms by number, they constitute about 90% of all atoms. They also constitute 63% of the number of atoms in your body (10% by mass). As has been said, hydrogen is an odorless, colorless gas that, given enough time, becomes you. And me.

Helium, with two protons and two electrons each, formed about a quarter of all atoms' mass that then existed (9% by number). There was also a dash of deuterium, or heavy hydrogen (one proton, one neutron, and an electron), helium isotopes, and lithium (three protons and electrons). It's possible that a handful of other atoms existed as well. Vast primal clouds of hydrogen and helium atoms, millions of light years across, still majestically float in certain areas of space nearly 14 billion years later. Some have gone on to form greater complexity; many have not. As Eric Chaisson has pointed out, "Far many more atoms are alone and isolated; only ~0.4% of the universe comprises bound atoms within complex, structured systems, roughly ten times that is loose baryonic (yet still normal) matter, which floats amidst the intergalactic beyond (all else, i.e., the remaining ~96% is "dark," at least to our senses.)" Sometimes complexity emerges; more often it doesn't.

Once formed, and left on their own, these atoms tended to keep their distance. While the strong force bound quarks together and protons and neutrons together within atoms, these atoms left to themselves generally liked their own company. They might approach each other as they moved about, but usually swerved off, avoiding connections with each other.

We sometimes hear about an "atomistic society." This usually refers to a rather asocial condition in which individuals have little to do with each other. The analogy might be a billiard table, with hard billiard balls usually sitting by themselves, but occasionally knocking into each other, sending each other off in various directions. Atoms may be the basic building blocks; but in our experience, blocks usually just sit there by themselves. We are each made of about $6.7*10^{27}$ atoms. What are we then like at our most constitutive level? Are we like the individuals discussed by Hobbes in the *Leviathan*? Do we live lives largely isolated from others? The only natural relationship is hostility; a war of all against all. By nature, are we as asocial as atoms? Should Libertarians seek out new sympathizers among the universe's vast majority of unaffiliated atoms? If we seek to form relationships, do we need to find ways to overcome our natural proclivity for individualism? Are atoms the ultimate existentialists, destined to live lives of lonely desperation and then die alone? On a dark, rainy night. And since we are built from atoms, is that what we are really like, all niceties aside?

But what if the story of which we are a part is one of emergent communitarianism rather than the individualism so celebrated in Western Liberalism.? Recall that even the simplest of atoms – those that have only one or two protons and are still the most abundant in the universe – are each a set of sustained, structured relationships. Quarks which just moments before had not existed, started to be related through the exchange of gluons mediating the strong force. Atoms, which had not existed before the big bang plus 380,000 years, added a relationship between protons and electrons. Atoms are sets of sustained, structured relationships.

At our most constitutive core, we are built more from relationships than from building blocks. Quarks and electrons are more fuzzy than blocky. Their "hardness" comes from forces defining their relationships. What exists between things is as real as the things themselves.

3.1.2 Stars

But what about atoms naturally avoiding each other? Relationships within atoms are fine, but beyond that, they naturally stay at a distance. Well, atoms are not left to their own devices. They exist within a larger framework that acts upon them.

When they did form, atoms were not perfectly distributed, if by perfect you mean absolutely equally. They were a little more densely distributed here, a little less there. This asymmetry, unequal distribution, or imperfection was another very fortunate occurrence. Inequality can contribute a lot. Gravity has no force at the relatively small distances between quarks. However, the space between slightly densely packed atoms can be just enough to let it start operating. A larger clump of atoms here can exert gravitational attraction on a smaller clump there. If all atoms had been equally distributed, their gravitational attraction on each other would have canceled it all out, and they would never have been drawn to each other. However, with the asymmetry, the denser regions could start drawing in the slightly less densely packed atoms. Gravity kept pulling them together, increasing their density and heat. (It may be that there just is not enough normal matter to have created enough gravity to have had the effects that we will soon see. It seems to be that there is "dark matter" that actually creates the additional gravity necessary to form the universe's structure that developed.)

As atoms were pulled closer together, they began to spin faster like a figure skater drawing in her arms. Once sufficient density and heat developed, with atoms moving about more and more quickly, the atoms overcame their preference to stay away from each other. More accurately, the Coulomb barrier refers to the electrostatic interaction that two nuclei need to overcome so they can get close enough to fuse. The protons needed to "tunnel" through this barrier to overcome the Coulomb barrier and fuse into one heavier element. The result of the quantum tunneling was to produce a two-proton helium nucleus. all held together by the strong force. Most protons remained separate, but enough fused to maintain a star's fusion reaction.

Each newly fused atom was less than the sum of its parts. Each new helium atom weighed slightly less than the two hydrogen atoms which had combined to form it. The missing matter had turned into energy. The fusion caused energy to burst out. Gravity kept trying to draw the atoms in. The uneasy equilibrium between these two forces resulted in the formation of stars. The black sky began twinkling. The dark age was over.

As the helium was formed, gravity drew it in more, until it heated up enough for it to start fusing into heavier elements, such as nitrogen. This released energy and permitted gravity to draw the newly formed elements further in, until they too began to fuse, forming carbon and neon. This was repeated as oxygen, magnesium, silicon, and sulfur were each fused. The largest stars with enough mass to permit gravity to keep drawing the newly fused elements further in developed an onion like structure, with the lighter elements on the periphery; the heavier ones successively formed layers closer to the core. Not only can there be new things under the stars, the stars themselves were something new. The strong force, electromagnetism, gravity, and fusion formed relationships between atoms within the structure of a star.

Gravitational attraction between stars and dark matter formed galaxies or groupings of stars in distinct patterns. Galaxies formed relationships due to gravity in local groups and even larger patterns. The theoretical work of Fr. Georges Lemaître, confirmed by the evidence collected by Edwin Hubble, demonstrated that not only were there more galaxies than our own Milky Way, but that once they got to be further away from each other than those in the local group, they are racing away from each other. It may be that dark energy or anti-gravity is causing the galaxies to keep falling out, with space and the universe expanding at ever faster speeds the further from each other they are. It may also be that the relative amount of dark energy has been changing over the course of universal history.

When the largest of the stars began to make iron with its 26 protons, energy was consumed rather than released. The equilibrium between gravity and fusion was broken. Almost immediately, the star exploded in a supernova. The sudden increase in temperatures during the explosion permitted the almost instantaneous formation of all of the elements with more than 26 protons per atom, all sent streaming into space at incredible speeds, often mixing with pre-existing clouds of hydrogen and helium that had been floating since the big bang.

3.1.3 LIGO and NANOGrav

Another way of forming all the elements in the universe could come from the collision of neutron stars, which could be detected a billion or more years later as having also produced gravitational waves. In 2016 the Laser Interferometer Gravitational-Wave Observatory (LIGO) detected the gravitational waves predicted by Einstein a century before. Two observatories used mirrors that were placed four kilometers apart and could detect a wave of less than one ten-thousandth the diameter of a proton that had been traveling across the universe for a billion years since two neutron stars collided. Adam Frank (2023) lyrically writes of observations of the North American Nanohertz Observatory for Gravitational Waves (NANOGrav):

> *The whole universe is humming. Actually, the whole universe is Mongolian throat singing. Every star, every planet, every continent, every building, every person is vibrating along to the slow cosmic beat.*
>
> *That's the takeaway from yesterday's remarkable announcement that scientists have detected a "cosmic background" of ripples in the structure of space and time.*

In addition producing waves, colliding neutron stars are, along with fusion within stars, another way of fusing elements with fewer protons into element with great numbers of them, or virtually all the elements. So your gold ring could have been made in a supernova or in a neutron star collision. In one way or the other, we get the full range of atoms.

3.2 Chemistry and Molecules

Atoms form in such a way that electrons orbit protons in shells. The innermost shell is full with two electrons, the second with eight, the third with eighteen, the fourth with thirty-two, the fifth with fifty. Hydrogen, with its one electron, has a vacancy sign out in its only electron shell. That shell seems to want one more electron to form a full house. Oxygen, with its eight electrons, has two in its first shell and six in its second. This leaves two vacancies in its second shell. This is a match made in the heavens. If two hydrogen atoms hook up with an oxygen atom, each sharing their electrons, each hydrogen atom can have two electrons in its only shell and oxygen can have 8 in its second shell. Everybody is happy because a new relationship between atoms is formed: H2O – water. This molecule has a new property. At the right temperature, it has the property of wetness, which did not exist before. Water, which is abundant throughout space, is not the only molecule that forms. Dozens of molecules with 2, 3, 4, 5, or more atoms evolve naturally. Many atoms due to the way electron shells work led to the formation of these new relationships called molecules.

Not all atoms are anxious to form molecules. Helium has two electrons in its only shell and has a No Vacancy sign well lit. It is called a noble gas. Having all they need; nobility does not require additional relationships with the lesser types that are needy. Relationship added to relationship is not much part of helium's story. While hydrogen becomes us, helium often just goes floating off into space. Not everything is social. Not everything forms polity, or sustained, ordered relationships. We saw that same aloofness with four of the six quarks. A subatomic particle formed in nuclear fusion, neutrinos, are much the same. Like photons, they go shooting from stars off into space, but almost never interact with anything. They can sail through twenty miles of lead and never hit anything. It has taken extraordinary measures to detect them at all. History and polity are not built on the backs of two thirds of quarks, neutrinos, helium, or other asocial phenomena. They are indeed the rugged individualists of the universe. The story of emergent complexity is not uniform.

3.3 Geology, Earth

After a nearby supernova shot its star dust out into neighboring space, disturbing pre-existing clouds of hydrogen and helium, gravity again began pulling together the mixture of elements and molecules. A second-generation star with mostly hydrogen and helium but also with traces of heavier elements in it – including oxygen, carbon, neon and iron – eventually began shining. This process may have been in its third round when our sun formed 4.6 billion years ago. It is not big enough to permit gravity to create densities high enough to fuse elements heavier than helium. This is good for us, since huge stars live fast and die young. Our sun goes along at a nice leisurely pace of fusing 600 million tons of hydrogen each second, turning it into 596 million tons of helium and more energy than mankind has ever produced in our species' entire history. It is because of all their mass that stars like our sun produce so much heat and light. Surprisingly, once you get down to the energy released bit by bit, the energy density flow is about the same as a reptile's metabolism.

The sun's rate of consuming its stock of hydrogen will permit it to continue shining for a total of about 10 billion years, meaning it is at mid-life now. Its five-billion-year history has provided energy and the time for earth to develop. We've got billions more years before the sun turns into a Red Giant, evaporates the oceans and engulfs the earth. There is time before anyone needs to get tickets for a trip to another solar system.

While gravity drew together 99.86% of the total mass of the Solar System to make the sun, the left-over debris was put to good use. On the outskirts of the spinning disk that eventually ignited as the sun, these leftovers from part of the supernova started accreting through the power of gravity. Gases and chunks of iron, nickel, silicon, and bits or gold, silver, uranium and other elements and molecules bumped into each other and stuck together. The planets, planetoids, comets, and asteroids were formed. On the emerging new Earth, all this knocking together that created kinetic energy, not to mention the radioactive decay of uranium and other such elements. This made for a molten, hot planet that formed its own structure from thousands of molecules and the minerals they produced. Heavier iron and nickel sank into a dense core that is still as hot as the surface of the sun. Silicon and other lighter elements rose to the top. Eventually, a thin layer made of basalt made for oceanic floors and the frothy granite cooled enough to permit land to form. Lighter, cooler outer layers spinning around denser iron and nickel produced a magnetic shield around the planet that protected it from solar winds that might otherwise blow away earth's atmosphere.

3.4 Biology and the Emergence of Life

The process of chemical evolution that had begun in space continued on earth. The most common elements on the surface of the earth continued to combine in many ways. Hydrogen, carbon, nitrogen, oxygen, sodium, magnesium, phosphorus, sulfur, chlorine, potassium, calcium, iron, and other elements on earth interacted to form over 4,700 minerals. Around black smokers at the bottom of the oceans where tectonic plates separated and mineral rich heated waters bellowed up, on the relatively cooler white (alkaline) smokers, or on sun-soaked pools of water on rocky beaches, the process of chemical evolution continued. Lipids that created films formed, eventually forming membranes. Carbon, with its four electrons in its second orbit and a total of six overall, was able to combine with many other elements, and was central to the Krebs cycle which spins off amino acids. These molecules continued to combine until they integrated membranes, metabolism or access to energy, and RNA and DNA that permitted reproduction with variation in response to environmental changes. The Last Common Universal Ancestor – LUCA – was combined in the most complex relationship in universal history to date – that we know of. The first prokaryote cells were earthlings, formed of the commonly available chemicals and elements on earth's surface. They were also children of the universe, with elements forged in stars that had died long before.

3.4.1 Biological Evolution

It has been said that the dream of every bacterium, the simplest of cells, is to become two bacteria. Reproduction has to be important for any species that plans on surviving, since the death of any given individual is part of the way life works. Sustained relationship is not eternal relationship. The nice thing about being a bacterium is that your dreams can come true about every twenty minutes. Reproduction with variation in response to environmental changes is a skill perfected by prokaryote cells. You just can't argue with success. They live in virtually any setting, however extreme the condition on earth can be. From deep underground to thermal waters, prokaryotes are there. There are more bacterial cells in and on your body than there are cells that constitute your body. They help you digest food. And when you die, they will digest you. These types of cells have survived for almost 4 billion years. They will be on earth long after humans have vanished. Many prokaryote cells follow a plan that isn't broken and doesn't need fixing, although they do keep adjusting to new conditions such as antibiotics. They evolve quickly, but as a group, they have not become fundamentally more complex.

However, after a couple billion years of happily reproducing at their same level of complexity, some did become more complex. A prokaryote cell may have tried to eat and digest a mitochondrial, but instead somehow managed instead to form a long-lasting and mutually beneficial relationship with it instead in a new, more complex type of cell. About two billion years ago, eukaryote cells appeared with a membrane covered kernel in which more complex DNA was kept. Hosting the mitochondrial cell created a new way of obtaining energy; it was now able to burn carbohydrates and eventually permit us to enjoy eating donuts.

A more complex set of relationships within the cell led to more complex relationships among cells. Films of bacteria on the surface of the ocean or accretions of them in rock like formations of stromatolites in tidal pools were steps towards multicellular life forms. One generation of cells died off, only to be covered by future layers of descendants. Another step in multicellular cooperation came with creatures like sponges. These are formed by the same type of cells that could still specialize in serving different functions. Some cells drew in nutrient rich water, others expelled nutrient drained water. Same type of cells; different tasks. Push these cells through a sieve so that they are separated as they fall to the bottom of a tank, and they scoot back together to form another new sponge. These are cooperative cells, not hardy individualists.

Relationships among increasingly complex body structures formed by different types of cells are seen in such examples as cnidarians, or jellyfish, first seen about 800 million years ago. They have little harpoons that can inject prey with poison, have such structures as a mouth / anus, and have two layers of tissue. Their nervous system is pretty uniformly spread out throughout the animal. Jellyfish are still around and doing fine. The Scarecrow in the *Wizard of Oz* seemed to get along pretty well without a brain, and so have the cnidarians. They have existed 4,000 times longer than *homo sapiens* have. They see no reason to develop more complexity.

Still, there were additional mutations that worked out in the environment of the time. Flatworms introduced a body plan about 590 million years ago with a right and a left side, an up and down, and a front and a back. Sense organs were put up front, along with a ganglia of nerve cells to interpret the incoming data. Chordates like the currently existing hagfish put a cord along its back to protect the flow of information from the ganglia to the rest of the body, as well as putting the mouth up front and an anus in the rear. About 525 million years ago, vertebrates started breaking that cord into bony segments, offering better protection and definition. The first animals to venture out from the seas onto land, such as Tiktalik, had wrists to help scoot on land and a neck to help look around. About 360 million years ago, the first amniotes could recreate the watery world in which reproduction had originally taken place, and start producing eggs with a protective shell and watery interior. About 360 million years ago, mammals first appeared, which had, among other things, a more complex auditory system with more parts that helped them hear better. The story of evolution is in part a story of increasing complexity of body structures, with more complex relationships among greater numbers of parts.

3.4.2 Relations among animals and plants

Relationships among quarks, protons and electrons, atoms, molecules, cells, and body parts were followed by increasingly complex relations among and between species. Edward O. Wilson's *The Social Conquest of the Earth* analyzes this phenomenon. From quorum sensing of bacteria to schools of fish, bee hives, ant colonies, flocks of birds, herds of bison, troops of chimpanzees, and many other examples, animals often live in groups and groups often form ecosystems.

Not all animals live in groups. Many seem to exist in splendid isolation for most of their lives, coming together just long enough for reproduction without any care for offspring after birth. Mother guppies and sharks would just as soon eat their babies. Sea turtles lay their eggs on the beach, return to the sea, and may hope for the best for their offspring, but likely don't think about them. Crocodiles help their offspring out of their eggshell and out of the nest; after that, the kids are on their own. Childcare is of course more of an issue for various lengths of time for many species. From weeks of care to a couple years is common. Mothers, fathers, and others are involved in different ways, depending on the species.

3.4.3 Physical Anthropology and Hominins

By the time we get to hominins, our ancestors' survival strategy and increasingly complex sociability went hand in hand. *Australopithicus* and its ancestors were the hunted rather than the hunters. They may have scavenged, eating bone marrow of leftover carcasses, but gathering fruits, nuts, tubers, and leaves likely provided a main stay of their diet. Other than that, they tried to stay out of the way of predators.

They had few natural weapons. Their teeth and fingernails were no match for lions. Their speed was no match for cheetahs. They had no shells for defense nor wings for flight. No wonder that there do not seem to have been huge numbers of hominids, that most species went extinct, and that our own ancestors came close to extinction. They just did not have that much going for them.

Bipedalism may have been an advantage when a drier climate led to more savannah grasslands and fewer forests with tree to swing from. Standing on two feet exposed less of the body to the hot sun, made it easier to see over tall grasses, and freed the use of the arms, hands, and opposable thumbs. A parent could hold a child and pick fruit all at once. But every benefit comes with a cost. It also altered the skeleton, restricting the birth canal, making child birth more painful and dangerous.

This problem was aggravated as hominids' greatest advantage developed. Brain size from *Australopithicus* to *homo sapiens* tripled, with Neanderthals winning the brain size competition. (Brain size for *Australopithicus* averaged between 375 and 550 cm3, *Homo habilis* from 500 to 800, *Homo erectus* 750 to 1225, *Homo Sapiens* 1200 – 1750, and Neanderthals 900 – 1880.) Hominids couldn't outfight competing species, but they could start to outthink them. Brains rather than brawn would eventually win the day.

The development of the hardware enabling life forms to think reaches back to bacteria using their flagella to scoot towards light and away from toxins. From there to hominin brain development is a long process. Brains gave species from jellyfish to humans all kinds of abilities. The eighteenth-century naturalist, Carl Linnaeus, first placed us as *Homo sapiens* within the Latin binomial nomenclature he developed for species. There are other types of men, but we are wise men. Our brains are what we most identify with. They grew in size and complexity; but why? Maybe it was originally because earlier species were *Homo habilis* – handy men who developed and used tools. It is the technological prowess that our brains gave us that is our central advantage. Or maybe it was a positive feedback loop between greater brain sized and complexity that permitted and was selected by more complex social relationships and cooperation that provided what little advantage we had early on.

Even with only partial brain development and soft skulls at birth, delivering children had become highly risky. To permit time for the brain to develop to maturity, grow a fused, bony skull, and learn all that they required to survive, childhood for hominids took years. Breastfeeding and childcare-giving mothers developed close relations with offspring over long childhoods.

Child mortality was still likely high. For a handful of children to reach sexual maturity, birth would need to be given to a number more. Especially for those with life-spans in the 30s or so for adults who got through childhood, this meant that most or all of a female's adult life was involved with pregnancy and childcare – and more. Working mothers were the norm. They likely provided the bulk of the calories through gathering and carried out many other important tasks. Still, they would have needed support as they did the primarily important work of getting children to adulthood so the species could survive. Long term relations between mothers and children and between child care-taking females and males were necessary for the fat-headed hominids to survive.

It is one thing to get together briefly to copulate. That is all sharks need to do since childcare is not a problem. Once they give birth, offspring on their own. A sea turtle female lays its eggs on a beach and never sees her offspring even hatch. Hominins faced a wholly other set of problems. Long childhoods required care-takers to work together for many years to raise children, a problem that hominins had to figure out if the species was going to survive. Resolving the issues of food, shelter, and other necessities for a kinship group over years takes problem solving and relationships to a whole different level. The increased demands of a long childhood and the long-term adult relations it required selected for an increased ability to figure out how to live together for many years at a time. The gender relations made necessary by being a big brained bipedal species is a root of hominin polity. Sexual politics has changed markedly recently with longer life spans and lower mortality rates. Mothers no longer spend their entire adult lives dealing with pregnancy and childcare and have the time and energy to do much else.

As Michael Duffy, who writes within the Montessori tradition, notes that as we go through evolution, "organisms produce fewer and fewer offspring and require longer and longer periods of care, leading to more important and deeper relationships. Fish produce thousands of eggs and rarely care for their young, reptiles produce hundreds of eggs and have only limited contact with their offspring, most mammals produce only a litter of a half dozen young and care for them for a long time through nursing, and humans have one or maybe two babies at a time and produce the most parent dependent creatures on Earth!" (Gustafson, 2013).

Many species have long developed their own ways of developing and maintaining relationships. Baboons groom each other, checking for parasites in the fur. Frans de Waal discusses how bonobos use sex for much the same purposes. Social primates, who were not genetically identical like ants within a colony are, developed a "theory of mind;" they could understand each other's reactions. They could even sometimes "feel for each other," or empathize. The law of the jungle, as de Waal argues, includes the social practices and understandings that would later be self-consciously developed into ethics.

Picking lice out of children's hair and having sexual relations has forever been part of hominid mothers' lives as well. Hominids' survival strategy led to developed abilities to relate to each other. For their relations to develop, they would need to exchange a lot more than just gluons and photons. If you thought physics was hard to grasp, just try politics as previous types of hominins evolved in *homo sapiens* with all the complexities of human memories, imagination, symbolic thinking, trade, and culture.

3.4.4 Migration

In addition to the relationships among genders for the purpose of child raising has been the relationship of hominins and other species with the land that supports them an on which they make their nests of various sorts. When land can no longer support the number of people living on it, that is one common reason for some of them to move to new territory. Hominins were not the first group of species who intentionally migrated. Queen bees will look for a new place to nest. Matriarchs will guide elephant herds to water over long distances, often making adjustments to age old routes in response to changed circumstances. As noted earlier, prokaryotes with flagellum seem to move intentionally. Movement in response to environmental changes requires complex thinking at various levels. It is a form of creative activity. *Homo erectus* migrated by about two million years ago from Africa to as far as Asia. *Homo sapiens* left Africa about 70,000 years ago. From the time that some humans left Africa, perhaps due to climate changes that were making available food sources more limited, people gradually spread out to inhabit the entire world, except for Antarctica, over the next 50,000 years. Humans reached the Americas via Beringia by 15,000–20,000 years ago. The many cultural adaptations that made survival in varied geographical and climatic variations are made possible by cognitive abilities. Piecing together now through the use of archaeology and genetic analysis, we are able to reconstruct the movements of people into new territories. The current story is one of very early human creativity, imagination, and courage.

3.5 Cultural Anthropology: Memory, Imagination, Symbolic Thinking, and Exchange

Defining what humans are is notoriously difficult. But somehow it includes a collection of physical characteristics such as bipedalism, opposable thumbs, a large brain, and smaller teeth. It also entails some combination of behaviors and cultural characteristics, such as memory, imagination, symbolic thinking, exchange, and empathy or having a "theory of mind."

3.5.1 Memory

Memory is an incredibly complicated topic. Virtually all species remember, although in very different ways. The long childhoods in which each person remembers their period of dependency creates long term memories of caretakers. Hominid adults still remember their own childhoods and their caretakers. They remember how these important experiences were carried out by those who are now old or dead. What was so important is now gone, but remains important in memory. Memories of what is no longer may be pondered while going about present tasks.

Child bearing for hominids also entails the expectation of repeating a long term set of relationships. I am going to have to do for my children what was done for me. This baby will require years of nurture to get it to sexual maturity. What is a baby now will in a number of years become an adult if I do what I need to do to help it survive. I can imagine a long-term future which does not yet exist, but which I can help create. Memory, imagination, planning, and execution go hand in hand.

3.5.2 Symbols and Language

Being able to remember what no longer is – and imagine what is not yet – is facilitated by symbolic thinking and language. Vervet monkeys will make one call for threats from above such as an eagle, another for threats in trees such as snakes, or those on the ground such as big cats. When one monkey makes such a call, others in the troop look in the right direction. One screech signifying eagle causes other monkeys to look up. A sound and an expressed / perceived meaning is linked correctly, helping the group's survival. However, the monkey does not make the sound in the absence of the threat. It does not discuss how to better prepare for a future threat. Vervet monkeys do not sit around at night discussing that day's eagle attack. They do not draw pictures of eagles. They do not intellectually manipulate or exchange symbols.

The development of syntax or grammar and vocabulary went along with that of symbolic thought. Being able to consider words and meaning in the absence of immediately present referents, adjust them, move them around and think of alternative arrangements, was facilitated by language. Being able to communicate these ideas in novel yet understandable ways meant that new meanings could be created.

Remembering and imagining in the absence of the referent is a source of symbolic thinking, planning, and eventually realizing possibilities. The road from the communication of monkeys to the symbolic thinking of hominids is long, complex, and still not exactly understood. But that it took place seems clear. By over two and a half million years ago at the Gona River in Ethiopia, *Australopithecus* or *Homo habilis* was making stone tools. Other species use tools as well. Crows, wolves, chimps and others will use stones and sticks to achieve various purposes. However, the Gona River chipped tools were fashioned by toolmakers. They had to first select which type of rock they wanted to alter. Some types of rock are too soft to make good tools. Then they had to be able to imagine the tool that was in the right kind of rock, to imagine how it could be made into a cutting, scraping, or digging tool. Then they had to carry out a series of steps to create the tool. This was probably done with others looking on and learning how to do this as well. And remember, all of this was going on over two million years before *Homo sapiens* appeared.

Tool-making was added to older tool-using skills when symbolic thinking and imagination was possible due to eye – hand and brain development, relative to earlier species. Those who had emerged from nature now began to adjust what they found in nature. Nature in these complex pockets called hominids could begin to select what helped them survive and live better. Evolution could begin to be not only in response to environment, but determinative of it. Nature became partially self-selecting in hominids.

Nature had long exhibited how creative it is. There was nothing and then there was something. There were not protons and then there were. Same with atoms, molecules, stars, terrestrial planets, and life. The transition from one to the next are times of change and natural creativity, but there were long periods of stasis in between each one. Relative to these periods, the time it took for hominids to develop their tool making was rather quick, even if it seems to be agonizingly slow to us. By the Oldowan period from about 2.6 to 1.7 million years ago, *Australopithicus* and / or *Homo habilis* had developed more sophisticated tools. By the Acheulean period about 1,650,000 to 100,000 years ago, tools had become bifacial, larger, and more varied. The oval or pear-shaped tools were not only functional, they also have shapes that are pleasing to us and perhaps to their makers. Natural emergence had become hominids' creativity. The road from physics to art was being paved.

Adjusting nature was done in various ways. Eating meat and tough tubers was hard on the digestive track of early hominids. Cooking them made them easier to digest and taste better. Exactly when this began is not certain, although it seems to have started between 1,500,00 and 790,000 years ago with the fire altered stones at Gesherbenot-Ya'aqov in Israel. The transition from scavenging to hunting had been made at least by a half million years ago, as indicated by spear points and skeletal wounds in prey found at Boxgrove, England and Kathu Pan 1 in South Africa.

3.5.3 Imagination

Burials indicate a new level of relationship. Other species such as elephants will clearly mourn dead members of the group. But the careful burial of the dead is a human activity. Again, exactly when this began is not clear, but there are burials from 80,000 to 120,000 years ago in Qafzeh, Israel. Here, we have living members of the group remembering the people who had died and imagining they have an obligation to them even after they die. Burial is a relationship with the dead, requiring memory of what is no longer. What is real in the present is only part of what matters. Memories of the past – kept in the electrical / chemical relationships among neurons – can be more important than the hard stuff that one can feel now in the present.

Hunters had long understood the difference between life and death. Causing an animal to bleed from wounds transformed the beast from one running through the woods to one lying on the ground. Did the hunters begin to think symbolically about the "life" being in the blood that sank into the ground? Does the life of the body go into the earth looking for a new form to inhabit? Is the spirit of the dead animal believed to be angry at the hunter, planning to return to the surface world to make trouble if proper steps of propitiation are not taken by the hunter?

Once grave goods become included in the burials, we seem to also have imagination of the future added to memory of the past. Burial goods suggest that people thought they could indeed take it with them. Everything had a spirit: people, mountains, rivers, pots, weapons, etc. The life or spirit of the dead person will need the spirits of various tools or weapons in the next life. Members of the group were socially close to those now dead. They remembered them and valued these memories. They wanted to imagine that their beloved would live on, and that proper actions by the living could help the dead live well. Ancestor worship may be one origin of religion. This seems to indicate the powerful social attachments our ancestors had with each other.

3.6 Art

The discoveries at Blombos cave in South Africa from about 75,000 years ago include an etched, rectangular rock. A net or diamond like design is scratched, with diagonal and parallel sets of lines. This is not just aimless doodling. This is done by a person interested in perceiving and creating patterns. What other patterns were being perceived and analyzed? Seasons? Plant growth? Movements of animals? Behaviors of fellow members of the group? Did the patterned lines have symbolic meaning of some sort in a way that etched crosses, six pointed stars, or crescents often have for us?

Shells with drilled holes were also found at Blombos. The cave is near the coast, and a diet of sea food sustained them. Did they wear the shells as a way to offer the spirits of the dead animals a place to live after their bodies had been ingested? Did they wear necklaces of shells out of a sense of beauty made possible by using or improving on what nature offers? What do these artifacts indicate about their symbolic thinking? By perhaps 48,000 years ago, at the El Castillo Cave in Spain, an artist painted animals and designs from dots and lines on the walls. This was the case later as well at Chauvet, Lascaux, and elsewhere. The animals that were painted were not modeling for them. The artists worked from memory. What purposes did they have in painting these animals and designs underground? What were the artists thinking about the animals and designs they painted? It is hard not to speculate. Was the cave where the spirits of dead animals went to live after their blood drained from their bodies? Were these spirits looking for new bodies to inhabit? What was the meaning of the paintings for those who drew or first viewed them? The artists also spit painted the outline of their hand multiple times. Were they leaving their signature, wanting those who would view the painting in the future to know who painted them? Were they touching the rock behind which the spirits of the animals they painted lived?

The importance of reproduction and fertility is made explicit by the so-called Venus figures found at Hohle Fels in Germany from the Upper Paleolithic period, the Woman of Willendorf from about 24,000 years ago, the Woman of Laussel from about 20,000 years ago and many others. These palm size statuettes of women with exaggerated breasts and hips may have offered comfort to mothers going through pregnancy or delivery, or had any number of other possible meanings. Whoever made the statues did so while thinking about fertility and sexuality rather than engaging in sex. These statues demonstrate symbolic thinking about sex in the immediate absence of sexual behavior.

3.6.1 Music

The emergence from sound to detecting sounds to creating sounds for communication and expression too is a complex topic. The hardware necessary to transforming the waves through a medium such as air into perceived sounds in the brain began with early land dwellers feeling vibrations in their bones. Sight is great, but you can't see around the bend or over the hill. Sound provides crucially important information. The patterns and tones of sound provide important information about the environment.

Many species produce sounds as well as perceive them. Some birds will sing to announce territorial claims or attract mates. Whales and others too will sing to communicate over long distances. Sounds can convey information to others.

With the malleus, incus, and stapes as part of their auditory system, mammals became able to hear in ways that reptiles cannot. Listening to the sound waves caused by ocean waves, lion roars, chirping crickets, and howling winds all had important meanings for hominids. Hearing and responding to a dependent babies cry, parting the lips and calling "Ma" with various inflections of tone elicited powerful responses among caretakers. Different sounds would have elicited other profound emotional responses, such as fear or sexual desire. Rhythmic music and drumming would have enhanced group identity during kinship groups' dances. Eventually, fife and drums communicated information and bolstered courage during battle. Campaign theme songs would identify candidates. National anthems would stir patriotism. Perceiving and making music has a long history of the relationships between animals and their environments, and animals such as humans with each other.

3.6.2 Creativity

Symbolic thinking and imagination made combination beyond natural referents possible. A wonderful example of this is the Löwenmesch or Lion Man from Germany from about 30,000 years ago. A bipedal man's body with a lion's head was not something the artist had ever seen. This was work not from memory alone but from imagination and combination. This indicates the ability to manipulate symbols separate from natural perception. It also indicates a crucially important political ability of combining what had not yet been combined in nature.

Nature had combined much in the past through increasingly complex relationships. Quarks, atoms, molecules, minerals, cells, body parts, animal groups, and ecosystems all kept putting thing together in larger and novel combinations. Now, humans could do this at a faster pace and self-consciously.

Placing value on symbols for their own sake was exhibited by early artists as well. For example, there is a beautiful ivory horse sculpture from Vogelherd, Germany from about 32,000 years ago. The artist did not try to include all the musculature of a real horse. Instead, it is an idealized shape with a series of flowing curves. This is not so much a representation of a physical horse as an ideal one expressing a sense of beauty. The artist took delight in abstraction. Plato was a bit of a Johnny-come-lately with his theory of the forms. Relationships through the exchange of words, music, and symbols developed human relationships. Exchange of goods did too. This too has a long history, going back to sharing food to enhance group relations. Specialized tool production homo habilis sites relatively far from sources of rock that were used indicates trade as much as two million years ago. Trading routes become increasingly extensive and established, until by 14,000 years ago the obsidian trade in the Near East and then the famous Silk Road establish what some see as a central core political system.

3.7 The Social Sciences and Development

Economics, sociology, and political science examine the emergence and structure of various ways of providing the material goods needed to sustain and enjoy life, groups of persons, decision making and implementation – the development of human organization over time. Humanity does not begin with the individual. It begins with the social structure required for our reproductive strategy to sustain the species – kinship.

3.7.1 Kinship

The growth of symbolic thinking and exchange of goods, words, glances, gestures, musical sounds, and artistic images facilitated political development. We have discussed the importance of kinship groups. Long term bonding of child care givers required sophisticated relationships demanding lots of exchanges. Kinship groups within a scavenger / gatherer and then hunter / gatherer economy likely became complex, but were still limited in size to perhaps fifty or a hundred persons. Larger trading routes would have permitted development of complexity of relationship. Family groups needed to exchange offspring for mating in the next generation. This led over generations to complex sets of inter-kinship relations. Terms such as "second cousin once removed" start to indicate such complexity.

In kinship relationships, lineage is important. Loyalties are to caretakers and common ancestors. Family and kinship remain important in our own day. The powerful resonances are indicated by larger groups attempting to appropriate kinship relations. Nationalists sometimes have referred to their country as a Motherland. In the United States, George Washington is referred to as the "Father of the Country." Members of the Roman Catholic church call their priests "Father." *Pope* is derived from the Greek *pappas*: father. Larger, non-lineage groups often seek to call upon the powerful forces of kinship. One of the values of Big History is its scientific story of the real lineage of all persons, going back to a small group in Africa about 200,000 years ago; of all life to LUCA, and the Universe to a single point. It turns out that we really do all have a common background. Big History is the scientific story for a period of Human Politics.

3.7.2 Agriculture and Villages

One of the major thresholds of Big History is the Agricultural Revolution. The transition from hunting and gathering to growing crops and raising certain animals is of crucial importance. It also entails a stage of political development. Hunting / gathering went along with kinship polities. With agriculture came settled villages of increasing size, beginning to include different kinship lines. This presented the village with an enormous political problem: how to establish a sustained, structured set of relationships beyond kinship.

One way to do this was to create dynasties; village lineages that all could be persuaded or forced to adopt. Lineage now became a symbolic political category rather than a biological one. In many regions of the world, mounds and other monumental burial sites enshrined the lineage of the village. Those within one lineage might still have the right to rule, but all needed to exchange the symbols that helped nurture loyalty to it.

The political leaders of these settlements or villages during the early agricultural era were sometimes those who had access and control over the best growing areas. We start to see increased social stratification and inequalities in wealth as the agricultural era proceeded. Some residences and some graves are noticeably grander than others. Hierarchy in the hunter / gatherer era was more likely based on strength, size, or cunning. In each period, leadership could also be exercised by those we call shamans, or those who could impress their fellows with their special insights and relationships. When some went through fasting, whether by choice or necessity, carried out rhythmic dancing while listening to repetitive rhythmic music, added various hallucinogens, and perhaps inflicted self-flagellation, they likely could report any number of special insights and experiences. Shapes would have shifted, experienced as traveling in other realms. These were similar to dream like states. Dreams while sleeping and trances while awake offered symbolic connections with what was beyond normal referents. Imagined relationships with abstract designs, ancestors, and the supernormal by some could have impressed others and established a claim to leadership.

Village identity could be developed and expressed through styles of clothing, certain verbal expressions, or other identifiers. Stories about the village could be told at gatherings. It took enormous effort and creativity to incorporate loyalty to the family within loyalty to the village.

3.7.3 Cities and Empires

Monumental, ceremonial architecture reinforced the claim by some of symbolic leadership that legitimized claims to leadership. Standing in awe not directly of the universe, but of some people's special connections with it were impressive. From Watson Brake in Ouachita Parish in Louisiana from about 5400 hundred years ago to Imhotep's Saqarra in Egypt about 4,700 years ago, grand burial sites began to announce the emergence of full-time leading families. Large, stylized burial mounds called attention if not of the gods, at least of the humbled onlookers who stood before them during ceremonies. Equivalents in modern America are the tall, stiff obelisk in honor to the Father of the Country, or the Jefferson or Lincoln Memorials in which political pilgrims can stand reverently in front of larger-than-life leaders who have mythical meaning and personify the presidential succession that leads to the current national leader.

Large, monumental architecture also announces the emergence of new political units of cities with larger populations and relations of cities within regional associations and nations or empires. Eridu, Uruk, Ur, Çatalhöyük, Jericho, Damascus, Mohenjo-daro, Tenochtitlán, Teotihuacan, Xi'an and other great cities represent a transition to larger, more complex political units. Sometimes these became the hubs of empires; sometimes they were combined with other cities within empires such as the Akkadian Empire of Sargon the Great from 2,400 BCE, the 15th century BCE New Kingdom of Ancient Egypt ruled by Thutmose III, the Assyrian empire of 2000–612 BCE, the Median Empire in Persia by the 6th century BCE, the Achaemenid Empire from 550–330 BCE, the Mauryan Empire from 321 to 185 BCE, the Roman, Han, Byzantine, Qing, Mongol, Arabian, Ottoman, Ashanti, and Mughal empires.

The modern European empires were transformative through their incorporation of the Industrial Revolution. The British, French, Dutch, German, and Japanese empires were built from steel, oil powered ships, railroads, gasoline powered vehicles. The Russian and American empires combined these in the Information Age with nuclear power and nuclear weapons.

Empires have survived for various lengths of time, sometimes lasting for a number of centuries. Imperial overstretch often exhausted them. This happened most recently with the Soviet empire, which broke up as many of its satellite states gained independence. It may be happening now with the American empire, with a state that is quickly becoming hopelessly indebted. Hundreds of US military bases add to a military budget that is equivalent to those of the next twenty states combined – and to US budget deficits that, along with entitlements and the interest on previous borrowing, add to the skyrocketing of American borrowing.

The struggles for power within empires and between some of them are the stuff of traditional history. The endless lists of battles and army flanks can make for a depressing account of the human past. Homer's account of the Trojan War is heroic enough, but it is also just another deadly battle scene. And things don't seem to have improved much. We started the twentieth century with a war to end all wars, followed by a horrific Second World War twenty years later. Since the end of WWII, there have been about 250 wars with over 50 million people killed, tens of millions more wounded, and countless made homeless. Emergence is at best a very mixed bag.

4. Multidirectional Emergence

The substantiated account from the big bang to ourselves today is a phenomenal accomplishment of humanity that can be told if the evidence offered by the disciplines in a university is integrated. How nations and civilizations emerged and developed are meaningful to many; placing humanity within our common universal context needs to be as well. The answer to the question of where we came from and how we got here is fantastic and as true as we can know it now. This account, told briefly above is marvelous in itself. It also may well have profound effects on its readers and listeners. Perhaps this story teaches us to be not only national citizens, but in a way, global and universal ones as well. All of us have common origins in the big bang, LUCA, and small bands in Africa.

However, complexity is not only a universal Great Chain of Being from the big bang to ourselves now. The big bang leads not only to our Milky Way, our sun, our planet, and our species - although it does do that as well. It also leads to many types of stars: main sequence, red giants, white dwarfs, neutron, and others (NASA, n.d.). Stars are often categorized by how hot to cool from O, B, A, F, G, K, and M. Each star within one of the letter classes is placed along a spectrum numeric spectrum from zero being hottest and nine being coolest. It leads to a trillion other galaxies of various types: spiral, elliptical, lenticular, "irregular, active, seyfert, quasars, and blazars." (NASA, n.d.). It leads to many other types of planets than Earth. Within our own solar system, there are gaseous and terrestrial planets of different sizes and structures. And in recent years we have increasingly learned about the range of plants in other solar systems about five thousand light years from us or less. These nearby Milky Way exoplanets are divided into four types: gas giants, Neptune-like, super-Earth, and terrestrial (NASA, n.d.). And then there is the matter of life forms in addition to humanity. There is a dizzying range of life forms on Earth, with astrobiology and habitable planets suggesting that there may well be an even greater number elsewhere. The universe has by no means developed in only one direction.

It is important to be well aware of how the universe has led to so much more than ourselves. If we think that we are the most important outcome, or the only one worth studying, we might wonder what is the point of the rest of such vast universe? Who needs galaxies billions of light years away? This sort of species solipsism is similar to the unfortunate existence of the pathological and narcissistic individualist who sees everything only in relationship to him/herself. Humanism is a valuable antidote to various forms of groupism; but it can lead to its own dismissal of the value of non-humans. A mature person is aware of, and values, other persons for themselves. A mature species cares about other species and other worlds. Reveling in a universal emergence that leads to so much other than ourselves is a joy. Studying and caring about the emergence of other species on Earth and other types of planets, stars, and perhaps universes changes and enriches our own perspective here and now.

4.1 The Humanities

The account of emergence of many different types of galaxies, stars, planets, life forms – and perhaps even other universes – creates a recognition of, and appreciation for, all kinds of diversity. There is no one privileged story in our story. When we measure the red shifts of other galaxies, it appears to us that we are at the center of the universe and everything else is racing away from us. However, if we were sitting in another galaxy, it would look the same. We are the center of the universe. So is every other place. We live within a magnificently large and complex and diverse whole.

This makes the universe story of complexity more consistent with post-modern humanities disciplines than is often thought. Post-modern scholars often see science and modernity as going together. The fear is that modern science is an attempt to establish claims to objective truth that are used to develop a grand narrative in the service of power. Modernity comes out of a mostly Western European process from the Italian Renaissance, French Enlightenment, English scientists and mathematicians as Isaac Newton and Charles Darwin, the German Albert Einstein, and many others. The intellectual hegemony of Western Europe dismisses non-Western cultures, a form of neo-colonialism.

As a rule, the sciences carry out experiments in laboratories in order to analyze nature. The humanities as a rule study and produce written texts in libraries and archives in order to examine and imagine humanity. As Carl Sagan (2020) said:

> *"What an astonishing thing a book is. It's a flat object made from a tree with flexible parts on which are imprinted lots of funny dark squiggles. But one glance at it and you're inside the mind of another person, maybe somebody dead for thousands of years. Across the millennia, an author is speaking clearly and silently inside your head, directly to you. Writing is perhaps the greatest of human inventions, binding together people who never knew each other, citizens of distant epochs. Books break the shackles of time. A book is proof that humans are capable of working magic."*

Among the key teachings of the study of the humanities, of reading books and other materials that have been produced throughout the world, is the stunning variety not only of the natural world, but also of the human experience. The big bang develops into many varieties of nature and human nature.

4.2 Static Levels of Complexity

So far, we have been tracing some of the thresholds or transitions between increasingly complex sets of relationships within relationships. However, it is usually more common for each level of complexity to remain more or less as it is. There are still vast clouds of unattached atoms of hydrogen and helium in the interstellar medium. They have not become anything more than that. There are vast numbers of planets that do not have the tectonic plates nor the layers that Earth has, and no live has emerged on them. On Earth, there are huge numbers of single cell organisms that have not become more complex life forms. The "Boring Billion" between 1.8 and 0.8 billion years ago showed minor tectonic developments, climatic change, and or biological evolution. Things can stay pretty much the same many times and places for a very long time.

Once we move into biological evolution, it is important to recall that there was no steady rise from simplicity to complexity. LUCA presumably was a prokaryote cell nearly 4 billion years ago. There are still enormous number of prokaryote cells that evolve without ever becoming eukaryote cells or multicellular life forms. With each new level of biological complexity, many species stay with their level without change. Sponges, cndarians, colelacanths, and many life forms that are millions and hundreds of millions of years old remain at their level of complexity.

Within humanity, there are many people who might be considered tribal or national and who have no interest in more complex forms of relationships. They count how many medals their nation's athletes win at the Olympics and care little for vague notions of the three values of Olympism: excellence, friendship and respect. which "constitute the foundation on which the Olympic Movement builds its activities to promote sport, culture and education with a view to building a better world." (International Olympics Committee, n.d.). Try finding a Human Passport that will get you through customs at the airport. There is no legal global citizenship.

At each level of complexity, from a hydrogen proton to nations, stasis is the more common part of the theme of complexity. There is often considerable time between levels of complexity if there is any emergence. In order to transition to a more complex relationship, it can at times take considerable energy and effort. For example, fusing hydrogen and helium into heavier elements takes enormous heat produced by gravity's creating greater densities. Moving from villages and cities into nations and empires has often required wars.

4.3 Greater Simplicity

In addition to the emergence of more complex relationships within relationships, multidirectional emergence, and statis, there is also a common experience of greater simplification. Relationships break down. Stars burn out and "die" or blow themselves up in super novae. Cells fail to relate as well as before and life forms age and die.

Various reasons for extinction have often killed off many complex life forms and sent the story back to simpler times. Five major extinction periods between 450 mya and 65 mya caused huge interruptions. And those followed the even more destructive Oxidation event. This is only part of the reason why over 99% of the species that have ever existed are now extinct. We may be going through a sixth (self-induced) extinction period that we hope does not conclude with our own species' disappearance. It would be a shame to be a mere 300,000 year-long flash in a pan. If we are, we may well have left an Earth with lots of extinct life forms and a host of simpler ones.

Dark energy seems to be pulling galaxies apart, perhaps followed by pulling apart even elements, and may pull everything apart into an end of existence as we know it. Origins and emergent complexity are more fun to discuss, but decline, disarticulation, collapse, endings, and death are just as real – and may have the last word.

Our sun will become increasingly hot until life on Earth may be impossible within a few billion years. It will become a Red Giant within five billion years, expanding until it evaporates Earth's oceans and fries any creature still hanging onto life. There will be a long universal future after the Earth is gone. However, eventually, dark energy may pull all the galaxies in our universe apart. Many keep vanishing beyond an event horizon, never to be seen again by us. Given enough time, most of the galaxies in our universe will have sped out of our view, leaving us with a mostly black sky. And then, our own local galaxies and even matter might come apart. William Butler Yeats (1919) and Chinua Achebe (2010) were indeed right; things do indeed fall apart. Or things get ripped apart. In the long run, everything. In this view, the Big Rip follows the Big Bang. It is not only we as persons and as a species that will end, it is our solar system and our entire universe – perhaps. And the Big Chill follows the Big Rip, with a return to absolute dark and cold. Or perhaps that is not the end.

4.4 Emergent Complexity from Conflict and Destruction?

There can mistakenly be a comforting feeling about emergent complexity, where it does exist. Optimists have long hoped that there is progress, that the arc of the universe is long, but it bends toward what is good, that it is getting better all the time. Emergence is often associated with violence of some sort. The beginning of the universe is probably misnamed, but the term big bang does not get the story off to a peaceful start. Gravity creating the densities that force protons together produce the fusion and energy of hug number of nuclear bombs going off every second just in our own sun. Exploding stars in their death throes, or neutron stars colliding, are needed to produce elements heavier than iron. Once we have biology, we have a never ending arms race. Creatures are endlessly creative in devising toxic chemical assaults, infections, harpoons, fangs, talons, wings, shells, brains, and any number of defensive and offensive weapons. Once we get to human politics, there is a bellicist theory of the state that sees that war has often made the state and the state often makes war. If humanity ever does get itself structured globally, it may well be an outcome of violent struggle.

4.5 Infinite Complexity

The end of our universe may lead to the birth of new ones. And new universes, some still born and others different from anything we can imagine, or others almost identical to ours, may be already be out there in infinite numbers. We have increasingly seen our own universe as so much more complex than we had imagined it to be. Now many suspect that our notions of complexity need to become infinitely more complex.

So, there we have it. Existence includes emergent complexity of relationships within relationships, the multidirection of emergence, stasis, emergent simplicity and the breakdown of relationships, or an infinite multiverse that is beyond our imagination. This draws on all the natural science, social science, and humanities disciplines of contemporary universities. It offers a theme that synthesizes knowledge rather than dissecting it. It points to a universe of knowledge that provides a rationale for a university. Every person from every location, every life form, every planet, every galaxy is included in the account of complexity. This is a story of unity and diversity, fact and imagination, and relationship and individual uniqueness that could reanimate a new idea of the university in our time.

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