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# From Particles to Politics

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**Abstract**

*In this paper we investigate the gradual and uneven development in the complexity of polity, or the sustained, structured relationships that incorporate earlier ones and go on to be subsumed by subsequent relationships. This takes us from the very early and long-lasting relationships among two types of quarks to the emergence of human polity, with annihilations, extinctions, and wars as part of the often unpredictable development. Can the study of this process add to the likelihood that it will move more thoroughly through the latest transition toward the greatest known complexity in polity, or will it face the temporary or even permanent effects of entropy?*

***Keywords:*** *Big Politics, polity and natural science, Big History and politics, politics and science, Political Science*.

Big Politics is the process of emergent complexity of sustained, structured relations that began with the Big Bang and has continued in stages through today, as it may continue to do in the future. The natural sciences explain how the simplest forms of sustained, structured relationships emerged and how they gradually, unevenly, and increasingly became more complex over time (Christian 2004, 2011; Chaisson 2006; Brown 2007; Spier 2010; Shubin 2013). Relationships have become progressively complex between sub-atomic particles, atoms, molecules, cells, morphology, animals, human families, villages and cities, nations, regions and empires. Each less complex and older set of relationships is incorporated within newer and more complex ones.

From the beginning, each new combination of units exhibits new properties. One significant new property was the emergence of consciousness and self-consciousness. Exactly how matter comes to be able to reflect on itself is still not fully understood, but the ability emerged out of pre-reflective matter. With this new property, conscious beings have played a greater role in choosing among alternative, imagined futures in ways that can create or inhibit further growth in complexity.

Politics among humans are certainly different from, but also emergent from, earlier types that vastly precede the relatively brief human period. Pre-written and pre-human politics are not mere analogies for human politics nor inevitable causes of it, but its necessary antecedents.

It is not possible to study the formation of atoms 300,000 years after the Big Bang and predict from that the writing of Plato's *Republic*. It is also a misperception that there is a great divide between human and prehuman politics. Human politics, much less politics before writing, did not emerge fully blown and without antecedents. The field of political science still needs to incorporate the story that the natural sciences permit us to tell, and not to begin its study with the ancient world of a few thousand years ago or even 200,000 years ago in political anthropology. As familiar as ancient political thought is to students of political philosophy and contemporary politics to those who use such methodologies as survey analysis, the study of political science can now vastly predate those periods. The study of light, rocks, bones, and blood as well as written texts, surveys, and electoral results, tell a story of the entire past from which human politics has emerged and remains embedded.

In one way, examining the relationship of politics and nature is nothing new. The famous ancient Greek philosopher, Aristotle, wrote books such as one on *Physics* and another on *Politics*. In the latter, he wrote that humans are by nature political animals. In the European medieval period, Thomas Aquinas developed Aristotelian thought on natural law; he argued that humans were created within a politically constituted community. By the seventeenth and eighteenth centuries, such State of Nature political philosophers as Thomas Hobbes, John Locke, and Jean-Jacques Rousseau postulated human politics before or without such institutions as the state. They wanted to determine how to construct states so that they helped resolve the basic problems of human nature. The authors of the U.S. Constitution saw their political construct as consistent with nature (Kammen 2006). For all of their differences, they all saw human politics as rooted in nature. None of them had the same understanding of nature as has developed since Darwin, Einstein, Hubble, and others in recent centuries.

The emergent complexity of sustained, structured relationships that incorporate earlier ones in new combinations and with new properties is possible due to access within pockets to high quality energy. The second law of thermodynamics would lead us to expect entropy, or transitions from greater to lesser order rather than emergent complexity, which is possible in energy rich pockets. From the origins of polity until today, we can observe in certain places a process of increased complexity due to the existence in certain locations of access to energy. If we can resolve our current energy crisis in a sustainable way, and if we have the imagination, this process may continue. However, there was no uniformity in emergent complexity in the past and there is no guarantee it will continue in the near future. In the distant future, we are virtually certain to face entropy. A narrative of humanity's common origin in Africa, life's origin from LUCA, and the Universe's origin from a singularity, may help foster greater complexity in politics among humans and between humans and our environment.

The major sub-fields of political science are often presented to students with discussions of their origins, structure, and emergent complexity. The origins of these sub-fields occurred centuries or even millennia ago. But our question here is not about the origins and development of American Politics, International Politics, Comparative Politics, or Theoretical Politics; it is about Politics. How has it developed greater complexity and become the human politics that we know today? What instruction might this provide for the future? Politics does not begin with the U.S. Constitution, the Treaty of Westphalia, or Plato's *Republic*. It began long before 1787, 1648, or 2,500 years ago. It cannot be studied only by public opinion polls since it began before any living person. It cannot be studied only by reading primary sources since it began before writing. It is not structured now just by written constitutions or by common law. Politics began long before in ways that continue to make us what we are today. Just as the past did not begin with writing or even with humans, so politics also did not begin with them. Our present and our politics emerge from much earlier antecedents that still includes them. Our well-being in the future may depend on our understanding this and acting on it. In the period since the origin of consciousness and culture, or collective learning, the persuasive narratives we tell ourselves and how we frame our stories become part of the evolution of emergent complexity.

**Baryonic Matter**

Sustained, structured relationships emerged quickly after the Big Bang, according to the standard view (Carroll 2012). The many complex properties that would characterize human politics were not inevitable from the sustained structure that began to develop 13.82 billion years ago (Planck 2013 Results Papers).

Perhaps, branes bounced or an infinitely hot and dense point without mass began expanding and cooling 13.82 billion years ago. It may be that nothing is always pulsating and is regularly turning into a variety of forms of something. Perhaps, we live in a multiverse with an infinite number of Big Bangs occurring all the time in ways we cannot detect or imagine. Other universes may be sharing our space or off in other locales. Or maybe our own universe has an infinite set of cycles of trillions of years (Singh 2004; Lederman and Teresi 2006; Greene 2011; Lederman and Hill 2011; Steinhardt and Turok 2007). We used to think there was only one galaxy. Then we wondered if there were other inhabitable planets. We now know there are great numbers of both. Why should ours be the only universe? However, for now we will restrict our attention to our own universe and to the development of polity.

At the earliest moment in our universe's known history, there was little discernible structure. If there was a singularity, it is hard to see how there was any structure in a point without mass. Ordered relations among parts did not begin until almost immediately after the Big Bang. If America was one nation formed by 13 former colonies and could adopt the Latin motto, *e pluribus unum* (from many one), the universe might adopt the opposite of from one many (*multa ex uno*). Incredible variation would emerge after the radiation period immediately after the Big Bang. Increasingly complex relationships between a relative few of these varied parts began very quickly.

All but immediately after our own universe's Big Bang, when energy first congealed into normal or baryonic matter, six types of quarks appeared. Four of these quarks led extraordinarily brief lives before returning to energy; they did 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.

At least those quarks that survived formed relationships. For a billion and one bits of matter that appeared, a billion bits of anti-matter with opposite spin did as well. When they come into contact, matter and anti-matter annihilate each other. This 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. Enough matter remained after the great annihilation 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. Destruction can be very creative.

The surviving quarks did not exist in isolation; they always exist in threesomes. Their relationship is structured by the strong force that is mediated by the exchange of the charmingly named gluons. Two up quarks and a down one form a positively charged proton; two downs and an up form a neutron. Why is the strong force exactly as strong as it is and not weaker or stronger? Is it different in other universes? It is simply not known. But if it differed at all, we would not be here and neither would anything else that we know of.

Quarks do not merge into one undifferentiated blob. Each proton and neutron is constituted by two different types of quarks. They relate to each 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. Both relationship and distinct identity are part of Big Politics.

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. As inventive and creative as nature is, it also keeps certain things around for a long time. Something seems to have come from nothing at the Big Bang. That is change. Quarks can maintain their relationships for tens of billions of years. You cannot get much more of a status quo than that. We see in the epic of evolution the combination of long periods of stasis connected by periods of transition to greater levels of complex relationships. Both the status quo and periods of significant development are part of Big Politics.

About three hundred thousand years after the Big Bang, when the universe had expanded enough to cool sufficiently, 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 per cent of all atoms. They also constitute 63 per cent of the number of atoms in your body (ten per cent by mass). As has been said, hydrogen is an odorless, colorless gas which, given enough time, turns into us (Harrison 1981).

Helium, with two protons and two electrons each, formed about a quarter of all atoms' mass that then existed (nine per cent by number). There was also a small amount of deuterium, or heavy hydrogen (one proton, one neutron, and an electron), helium isotopes, and lithium (three protons and electrons). 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.

Once formed, and left on their own, positively charged protons kept their distance from each other. While the strong force bound quarks together and protons and neutrons together within atoms, these atoms did not fuse. 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'. For example, political philosopher Russell Kirk wrote that 'Individualism is social atomism; conservatism is community of spirit' (Kirk 1960). Social atomism 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; 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 Leviathan? Do we live our lives largely isolated from others? By nature, are we as asocial as 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? And since we are built from atoms, is that what we are really like, all niceties aside?

But what if the story is one of emergent relationship as well as distinct identity? 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 a strong force. Atoms, which had not existed before the Big Bang plus 300,000 years, added a relationship between protons and electrons. Atoms are sets of sustained, structured relationships. They are the simplest of polities. 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.

**Stars**

But what about positively charged protons naturally avoiding each other? Two hydrogen atoms ($H_2$) might combine on their own by sharing electrons, but they do not fuse into helium as they float in enormous clouds. Helium did not combine with anything. One and two proton atoms by themselves would never on their own have led to us. To form larger, more massive atoms, a new set of relationships was required.

When they did form, atoms were not perfectly distributed, if 'perfect' means absolute equality. They were slightly more densely distributed here, a little less there. This asymmetry, unequal distribution, or imperfection was another very fortunate occurrence. Gravity has no force at the relatively small distances between quarks. However, the space between atoms can be just enough to let it start operating. A 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. As they 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. Hydrogen began fusing. They not only ran into each other, hydrogen nuclei could stick to each other, forming helium, with its two protons and two neutrons, all held together by the strong force.

The newly joined atoms were less than the sum of their parts. Each new helium atom weighed slightly less than the 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 equilibrium between these two forces resulted in the formation of stars.

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. In the long run, this may lead to the final disassociation of the universe and the end of polity. The continued development of polity within pockets of available energy is a medium-term possibility. In the long run, we and the universe may both finally succumb to entropy.

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 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.

**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 18, the fourth with 32, the fifth with 50. 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 eight in its second shell. A new relationship between atoms is formed: $H_2O$ – 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 lead 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 in our universe is not uniform and it may not be eternal.

**Earth and the Emergence of Life**

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 as our Sun 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 fuses 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.

The Sun's rate of consuming its stock of hydrogen will permit it to continue shining for a total of about, meaning it is at mid-life now. Its 4.6 billion year history has provided energy and the time for Earth to develop. Although the Sun will likely increase its output of radiation enough within two billion years to kill most or all life on Earth, it will be five billion before it turns into a red giant, evaporates the oceans and engulfs the Earth.

While gravity drew together 99.86 per cent of the total mass of the Solar System to make the Sun, the left over debris went 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. Chunks of iron, nickel, silicon, and bits or gold, silver, uranium and other elements and molecules bumped into each other and stuck together. All this knocking together that created kinetic energy, as well as the radioactive decay of uranium and other such elements, made for a molten, hot planet even on its surface. As its outer layer cooled, Earth formed its own structure from thousands of molecules and the minerals they produced. Heavier iron and nickel sunk 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 the frothy basalt and granite could cool enough to permit land to form. Lighter and 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.

The process of chemical evolution that had begun in space continued on Earth (Hazen 2005, 2012; Hoffmann 2012; Pross 2012). 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, 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. They were also children of the universe, with elements forged in stars that had died long before. We can look to the skies where one or more enormous stars exploded billions of years ago – and to the green scum covering the local pond – to see the equivalents of our ancestors. This might bring us a sense of both pride and humility. It also may elicit a sense of intimate relationship with all of nature.

**Biological Evolution**

It has been said that the dream of every bacteria, 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 cannot 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 four billion years. They will be on earth long after humans have vanished. Many prokaryote cells follow a plan that is not broken and does not 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 (Dawkins 2004, 2010; Lane 2009). About two billion years ago, eukaryote cells developed with a membrane covered kernel inside the cell in which more complex DNA was kept. It also maintained a relationship with a mitochondrial cell rather than having digested it. This provided an ability to burn carbohydrates and permits 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. Another step in multicellular cooperation came with creatures like the 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 jelly fish, 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. Jelly fish are still around and doing fine. 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 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.

It is worth recalling a few things. First, part of the reason for this development was in response to the bitter competition between and among species. An arms race of those seeking to eat others and those seeking not to be eaten was good to select which individuals would survive to reproduce the next generation. Increasingly complex relationship was spurred in part by sustained relationships that were harshly competition. Conflict, even deadly conflict, can spur greater complexity. Secondly, there was no steady rise from simplicity to complexity. Five major extinction periods between 450 mya and 65 mya caused huge interruptions. This is only part of the reason why over 99 per cent 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. However, virtually all species, including the human one, have gone or will go extinct as the evolution of life continues.

**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* offers a brilliant discussion of this phenomenon (Wilson 2012). 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 likely do not think about them after that. Crocodiles help their offspring out of their eggshell and out of the nest; after that, the offspring are usually 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.

By the time we get to hominids, our ancestors' survival strategy and increasing sociability went hand in hand (Tattersall 2012). *Australopithecus* and its ancestors were likely more often the hunted than the hunters. They may have scavenged, eating bone marrow of leftover carcasses, but gathering fruits, nuts, tubers, and leaves likely provided a mainstay of their diet. Other than that, they tried to stay out of the way of predators. They had few natural weapons. Their teeth were no match for those of lions. Their speed was no match for cheetahs. They had no shells for defense or 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 (Sarmiento, Sawyer *et al.* 2007). They just did not have that much going for them.

Bipedalism, for whatever reason it was adopted, did permit more use of the arms, hands, and opposable thumbs. A parent could hold a child and pick fruit all at once. But it also altered the skeleton, restricting the birth canal, making child birth that much more dangerous. This became a greater problem once the hominids' greatest weapon did finally start to develop. Brain size from *Australopithecus* to Homo sapiens tripled, with Neanderthals winning the brain size competition. (Brain size for *Australopithecus* averaged between 375 and 550 $cm^3$, *Homo habilis* from 500 to 800, *Homo erectus* 750 to 1225, *Homo sapiens* 1200–1750, and Neanderthals 900–1880.) It is not just brain size that is important, but how the structure of the brain develops and its size relative to body size. Hominids' enormous cerebral cortex permits the development of memory, attention, perceptual awareness, thought, language, and self-consciousness. With its development, polity emerges into politics. Hominids could not outfight competing species, but they could start to outthink them. Brains rather than brawn would eventually win the day.

But big brains come at a cost. 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 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. For a species with relatively few members, the group had a strong interest in reproduction. Especially 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. 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 and the kinship group could survive. Long term relations between mothers and children and between child care-taking females and males were necessary for the large skulled 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. It is a wholly other set of problems to stay together for many years to raise children, a problem that hominids did have to figure out if they were 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 hominid 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! (Duffy personal communication, May 13, 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 (Waal 1989, 2005, 2007; Waal, Macedo *et al*. 2006).

Picking lice out of children's hair and having sexual relations has forever been part of hominid mothers' lives as well (Wade 2006). 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.

## Memory, Imagination, Symbolic Thinking, and Exchange

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.

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 (Johanson and Edgar 2006; Kenneally 2007; Bickerton 2009). When a monkey makes such a call, others in the troop look in the right direction. A screech signifying eagle causes other monkeys to look up. A sound and an expressed/perceived meaning are linked correctly, helping the group's survival. However, the monkey does not make the sound in the absence of the threat. 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. With language, communication could nurture more complex forms of politics. Remembering and imagining in the absence of the referent is a source of symbolic thinking, planning, and realizing possibilities.

An important step in the road from the communication of monkeys to the symbolic thinking of hominids may have been tool-making. 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. Tool-making was added to older tool-using skills when symbolic thinking and imagination was possible due to eye-hand and brain development (Nowell and Davidson 2010; Shea 2013). Those who had emerged from nature now began to adjust what they found in nature. 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.

By the Oldowan period from about 2.6 to 1.7 million years ago, *Australopithecus* 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.

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 1,500,000 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.

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 touch 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.

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 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 (Bahn 1998; Lewis-Williams 2002; Clottes 2003, 2008; White 2003; Curtis 2007; Whitley 2009).

The evolution of music is noteworthy. 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 cannot 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 (Bernstein n.d.). 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.

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 things 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.

Relationships through the exchange of words, music, and symbols developed human relationships. Exchange of goods did too. This also 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 indicate 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 established what some see as a central core political system.

**Political Development**

*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 childcare 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.

In kinship relationships, lineage is important. Loyalties are to caretakers and common ancestors. Family and kinship remains 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'. Larger, non-lineage groups often seek to call upon the powerful forces of kinship. One of the values of Big Politics 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 Politics is the scientific story for a period of Human Politics.

*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 (Wenke and Olszewski 2007). Hunting-gathering went along with kinship polities. With agriculture came the emergence of chiefdoms and 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 whom 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.

*Cities and Empires*

Monumental, ceremonial architecture reinforced the claim by some of symbolic leadership that legitimized claims to leadership. Leaders may have preferred subjects to stand in awe not directly of the universe, but of the leaders' special connections with it. From Watson Brake in Ouachita Parish in Louisiana from about 5,400 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. The great ancient 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. 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, and 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 do not 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.

**Big Politics?**

What will replace America's unipolar moment after the end of its empire? Will it be replaced by another empire? A return to a multipolar world such as existed in Europe in the nineteenth century? Are we within a transition to a new level of complexity which incorporates relationships among quarks, atoms, molecules, cells, body structures, families, villages, cities, nations within a more closely related humanity within our common environment?

Some find hopeful evidence for such a transition occurring. The research into missiles starting in the Second World War and continuing through the Cold War is responsible for much of the technology that produced the Earth Rise photo, a banner for globalism ever since it was first taken by astronaut William Anders in 1968 during the Apollo 8 mission. Steven Pinker argues in *Our Better Angels* that we have experienced a promising trend of decreasing use of force. Humans are indeed capable, he argues, of exercising their self-control, empathy, morality, and reason. We have seen the emergence of government claiming a monopoly on force and violence. Many regions of the world have robust trading and financial relations. We have seen increased literacy, urbanization, mobility, and access to mass media. These have led to greater familiarity among cultures. There has been some increase in the rule of various forms of democracy. As bad as the many wars since 1945 have been, there has been no civilizational ending nuclear war. Twenty years separated WWI and WWII; we have gone 68 years since WWII without any WWIII. There is no reason for complacency yet, of course. It was a century between the Napoleonic Wars and WWI; so we have yet to equal the successes of the nineteenth century. Still, there maybe come collective learning about how to keep the peace.

The threat of environmental degradation, pollution, and climate change may have become more pressing that the threat of war. Decreasing reserves of fossil fuels and the carbon emissions from the use of those we have combine in an energy crisis. If this crisis cannot be solved in a sustainable way, the consequences could be negatively transformative. On the other hand, within the past generation, environmental concerns have gone from marginal to central for great numbers of people.

The hopes of those who established the United Nations frequently seem illusory, given that body's actual performance since the Second World War. Yet, the nations of the world continue to belong to it and even make productive use of it at times. We are very long way from a world government, but also a long way from international anarchy.

**Where are We Going?**

What can we conclude from our 13.82 billion year journey so far in this Universe? The access to high quality energy in certain pockets has permitted increased complexity in relationships between quarks, atoms, molecules, cells, animals, and humans within families, cities, nations, empires, and the world. Each of the earlier relationships continues to be part of our current ones, although often in transformed ways. You and I are the beneficiaries of the relationships that have been developed. We are made from the relationships among quarks, atoms, molecules, cells, and many intricately related body parts. We live within kinship groups, nations, and empires. Many of us are connected with others around the world through the almost instantaneous exchange of digital information. We have evidence for a common origin of all of us and indeed everything in the universe. All of us on earth have a common origin and we may perish together in a species wide extinction; all of life on earth will quite certainly come to an end together as the Sun becomes a Red Giant.

Will we continue to have access to high quality energy and remain as the pockets which continue to develop the most complex relationships of which we are aware in the universe? Can we use this energy without polluting our world and making it uninhabitable? Even if the energy crisis is resolved in a sustainable way, do we have the imagination to combine national, ethnic, and other types of groups within new and meaningful relationships? Can we be as creative as nature was earlier when it first combined protons and electrons, atoms in molecules, molecules in cells, cells in plants and animals, and animals in various groupings? Can we be as imaginative as the artist who carved the Löwenmesch, imagining the combination of lions and people? Or the shaman who imagined how to combine kinship groups in the village? Can the study of Big History be formative enough to teach us how to combine families, ethnic groups, cities, nations, empires, humans, and our environment in ways that protect all of them? Can this be done even while there are many in less complex relationships who show little or no interest in participating in Big Politics, who are satisfied with staying at their level of complexity? Can enough people make the transition to the next level of complexity? Can we fashion a more complex sustainable, structured set of relationships? A new Big Politics?

Or will entropy overtake us before it needs to?

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