

# BIG HISTORY AROUND US



  
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## Origins

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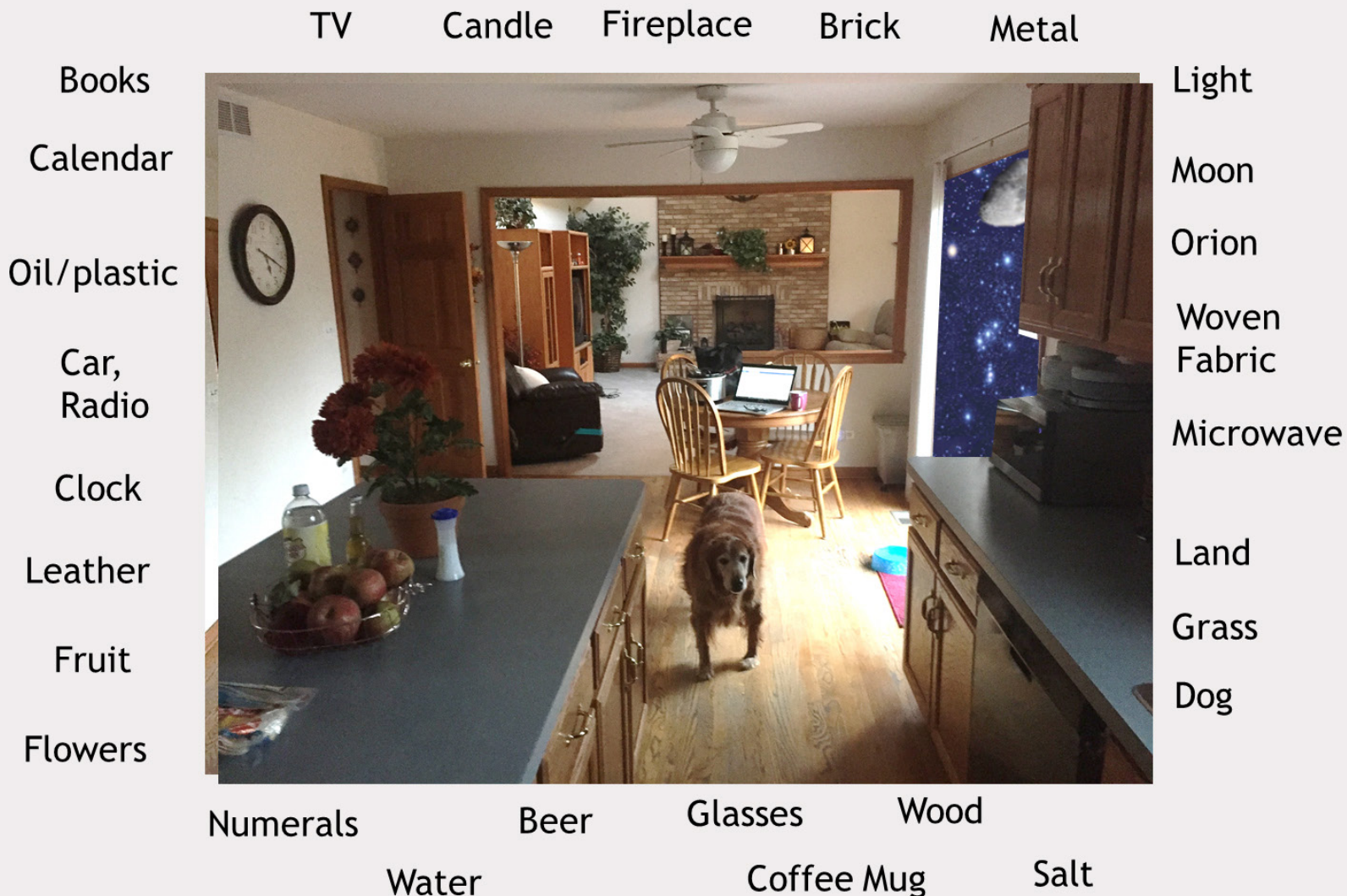
by

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While reading books on Big History (Christian 2018, Christian et. al. 2014) gives many details concerning Big History, there are reminders all around us of items and events in Big History. We start with an ordinary house photo and then, like a detective, search out the Big History clues in the photo (and around each of us). These everyday items have very interesting histories which are explored in the context of Big History. The topics include:

- Cosmos history: hydrogen, antimatter, cosmic microwaves, galaxies, stars, elements, planets/moon,
- Life history: iron, land, wood, oil/coal, flowers, grasses;
- Human evolution history: fire, dog, pottery/brick, bread/beer,
- Civilization history: alphabet, metals, calendar, hindu/arabic numerals, gun, watch, glasses, newspaper, clothes, electricity, radio, car, smart phone.



While this is not a typical search puzzle, the answers to why these items are so typical has a long and interesting history. Similar writings with more details include Bill Bryson's *Short History of Nearly Everything* (2003), Tom Standage's *History of the World in Six Glasses* (2005), Stephen Sass' *The Substance of Civilization* (1998), and Penny Le Couteur's *Napoleon's Buttons* (2004).

## **Cosmos History**

### *Protons*

The water bottle contains water, which is a molecule with hydrogen and oxygen. The hydrogen atoms have a proton in the center with an electron surrounding it. The proton formed in the first second after the Big Bang about 13.8 billion years ago. The presence of hydrogen from the Big Bang is quite surprising (to physicists) since a current physics mystery is why the hydrogen did not combine with its antimatter counterpart to make high energy light. In fact, almost all the matter of the early Big Bang did just that and we can see it as the cosmic microwave background (next section). In fact only 1 part in a billion escaped this demise to later form hydrogen atoms. Scientists are searching extensively to try to explain why this small part of matter survived. In the 1980's it was believed that protons might actually decay. After looking for such evidence in large pools of water deep in salt mines, no evidence was found.

### *Anti-matter*

You might think that antimatter is only found in deep space or in large scientific laboratories. However, it is in you, the environment, and traveling through the sky. The isotope of potassium, K-40, is found just about everywhere in rocks and food (especially bananas, bricks and salt). It was originally produced in a stellar explosion billions of years ago. However, some of that explosion's energy is still being released through the K-40 decay. Most of the K-40 decays through the emission of an electron from the nucleus, but a small fraction (1 in 100,000) decays through the emission of a positron, the antimatter partner of an electron. Besides this, there are cosmic ray particles that hit the at-

mosphere of the Earth forming a heavier cousin of the electron, the muon. One of these muons pass through your palm every second, with a large fraction of them being antimatter. The cosmic ray radiation causes a bit over 10% of each human's natural exposure to radiation. The detection of these muons requires specialized equipment, such as that loaned to high school students (through, for example, the QuarkNet Project) to conduct science fair experiments.

### *Cosmic Microwaves*

Turning on an antenna-based analog TV (which is very difficult to find today), actually displays some signal of the cosmic microwave radiation in the noise. That is if the TV were tuned to somewhere between the channels and the static could be seen, a small fraction of this noise is from the remnants of radiation that was generated about 400,000 years after the Big Bang, i.e., over 13 billion years ago. In fact, it was when some researchers looked into radio signals far from radio stations that they found a noise source that would not go away despite all their efforts. (These efforts included cleaning the antenna of bird droppings, which might have given a similar signal as additional dielectric material.) They eventually teamed up with cosmologists that had predicted such a signal and interpreted it as the cosmic microwave background. This background is somewhat similar to the embers of a fire that initially glowed white in the fire, but then cooled to yellow and red. The initial glow of the radio background was from cooling of the big bang's high temperature. However, the cooling was through the expansion of the universe, not by the cooler surrounding as in the fire embers.

Better detection methods were needed to construct an improved understanding, so satellites were designed to go into space where there was less noise. The amount of information gained from these measurements were tremendous, telling us about the almost uniform distribution, sprinkled with very small temperature differences. These were able to show a kind of a baby picture of the universe near the big bang where it is believed that quantum effects (usually only associated with the very small sizes) were responsible for the major structures of the universe.

### *Galaxy Formation*

Looking out the windows on a cloudless, moonless night are stars and maybe a couple of planets. However, there are some objects that seem to be a bit blurrier than others. One is the Andromeda Galaxy that can be seen with just your eyes. The light hitting your eyes was emitted about 2.5 million years ago when ancestors of early humans were just starting to travel around Africa. Just as we saw with the cosmic microwave background, the light hitting us from the sky has quite a bit of information including acting as a time machine, allowing us to look at how things (galaxies) were so long ago, since nothing blocks or scatters the light with a finite (but fast) speed.

There are still many questions about the formation of galaxies. It seems like many of them have a very large black hole in their center that sometimes can be actively “eating” surrounding stars and gas. It is still unclear how these large black holes formed so early in the universe. Another mystery of the galaxies is that the matter in the arms seems to be moving much faster than calculated given the amount of stars in the center. This is not the case, for example, when we look at the solar system, where the planets move according to the principles of Newton’s theory of gravity with the masses (mostly the sun). This anomaly resulted in the hypothesis that there is some matter that we cannot see and does not interact much (dark matter).

### *Star formation*

Now back to that water. We found out where the hydrogen was from- the big bang, but what about the oxygen? It took a while to form oxygen and other elements, such as silicon and iron (major components of the Earth). This occurred through generations of stars forming, burning, and then exploding.

While still looking into the night sky, the belt of Orion constellation and the stars of the sword hanging from the belt can be identified. The mid star is a bit fuzzy because it is not a star but instead a nebula, the Orion Nebula, which is part of a much larger nebula gas cloud that extends over an angle wider than the moon. The Orion Nebula is known to be a place of star

formation from the gasses (Croswell 2015). The origin of the nebula might be from supernova explosions, dispersing the heavier elements formed in the former stars core. These explosions might also help condense some of the existing gas into a gravitational mass that will cool to form new stars.

The energy that keeps the stars (and the sun) going for such a long time is the fusion of hydrogen nuclei into helium (Clayton 1968, Chaisson 2001). It is not too difficult to actually fuse hydrogen. For example, I worked for an oil exploration company where nuclear-based tools were used to characterize the underground oil formations. Some of these tools generated neutrons using a small glass tube that could sustain fusion by applying a voltage similar to what is needed in the old TV sets. However, that fusion took more energy to make happen than it generated, so it was not a way to generate electricity. Efficient energy production is very difficult since hydrogen needs to be contained at a high temperature and pressure to overcome the electrical repulsion. The sun, with a mass of about 300,000 Earths, does this with its enormous gravity. In the center 1% of the sun, about 4 million metric tons of matter are converted into energy ( $E=mc^2$ ) each day. In comparison, a small (World War II era) nuclear bomb converts about 1 gram of matter into energy.

### *Heavier Elements*

Many generations of stars were necessary to burn through their fuel, then explode releasing the material for recycling into new stars. To eventually form a long-lived star like the sun that has enough non-hydrogen material around it to form planets, heavier elements were forged by even more energetic astronomical events such as neutron star collisions. These give us gold and uranium. Uranium stores part of the energy of these extremely violent events within its nucleus. Humans figured out how to unleash this energy in the 20th century in both controlled (nuclear electricity generation) and weapons.

Later, carbon and oxygen formed in stars. However, a pair of helium nuclei cannot fuse together to form a stable nucleus. Instead, three helium nuclei must come together within a short time to form carbon. This re-



sulting carbon atom not only has a special nucleus that can form this way but also its 6 electrons form a very special structure that supports a wide variety of chemicals including the complex biological molecules in life such as proteins, DNA, and sugars. Later, further reactions occur including carbon, neon, oxygen and silicon.

Silicon is just below carbon in the periodic table, which suggests it should be chemically similar to carbon. However, because of the extra charge, the size of the atom is a bit different which results in much different chemistry. Silicon forms the majority of rocks on the Earth's crust. Later, it is a technologically significant element, much as carbon is to life, in its use as part of flint tools, clay, glass, semiconductors, and optical fibers.

### *Planetary Formation*

The planets were formed from the small fraction of the gas cloud that had not condensed through gravity to form the sun. Just as an ice skater spins faster and faster as they pull their arms and legs in, material would spin faster and faster as the sun pulled the material closer. Eventually, this spinning would hinder further condensation into the sun. Instead the remaining rock and ice material collided to start forming planets.

The moon kept records of these impacts as large craters. It is believed that the Earth and moon formed from the collision of two very large planet-sized objects. The moon is very strange compared to other moons in the solar system partly because it is so large compared to the Earth. Without the moon, life on Earth might be quite different because of its effect on stabilizing the Earth's spin and the tidal forces it has on the oceans.

Many questions remain about planetary formation, especially when compared to other observed planetary systems, which seem to have very large planets like Jupiter in closer orbits. Planets might have moved closer and further from the sun during formation due to friction or drag of the particles but later gain energy through interaction with larger outer planets. This Grand Tack Hypothesis is an analogy to tacking against the direction of the wind in a sailboat.

## Life

### *Water*

Water is one of the most basic but interesting of molecules. It is composed of three atoms but they are not aligned in a straight line. Instead, there is a bend of the two hydrogens around the central oxygen atom that makes all the difference. Usually lighter molecules are more likely found as gases compared to heavier molecules. For example, methane  $\text{CH}_4$ , which has a mass of 16 times that of hydrogen, is the major component of natural gas that keeps our houses and water warm. Propane used for grills has 3 carbons with attached hydrogens leading to a mass of 44 hydrogens, is still a gas at standard temperatures and pressures. It takes a molecule with 8 carbon atoms, Octane, a component of gasoline has a mass of 114 hydrogens, to form a liquid. When gasoline is burned, the products are water and carbon dioxide. The carbon dioxide has a mass of 44 hydrogens (same as propane) and is a gas. However, the relatively light water molecule with a mass of 18, about two and a half times less than carbon dioxide, is a liquid (it comes out of the combustion process as a vapor only because of the higher temperature).

Recent debate concerns the origin of water on Earth (AAAS 2020). It might have come from comets further from the sun where ice can naturally form. These comets might have then delivered the water when the Earth was cool enough not to vaporize it back into space. Another theory is that enough water can be held within interior rocks, which is then released later.

### *Iron*

Much of the easily mined iron, which has been important since the Iron Age, was formed by very early cyanobacteria. These bacteria had evolved a photosynthesis that split water and replaced the oxygen in carbon dioxide with hydrogens, which released oxygen into the environment. This was a problem however, since the oxygen caused oxidation (e.g., rust), which was a poison to early life. However, initially the oxygen rusted the dissolved iron in the ocean water, which then settled to the bottom. Alternating layers of regular sediment and this iron oxide formed bands of iron in

the rock. These bands formed the majority of our iron ore. When the dissolved iron had been removed from the ocean, the oxygen level began to build up in the atmosphere, causing the great oxygenation event about 2.4 billion years ago. This additional oxygen led to the capability for sufficient oxygen to diffuse through larger cells, which eventually enabled multicellular organisms to evolve.

### *Land*

The land that we now live on could be considered rather unusual. The Earth was once covered by water. However, the mixing of heated rock material in the Earth's mantle facilitated the separation of lighter rocks, like basalts, to the surface. The lighter basalts "floated" on the denser mantle rocks forming plates that were further processed through volcanoes and subduction. There are still many mysteries about the relationship of plate tectonics and life. Some say that life was needed to initiate plate movement (Slazak 2013). Others say that plate tectonics was necessary for life to form. However, plate tectonics did play a large role in later evolution in generating new environmental niches and recycling mineral nutrient.

### *Wood*

As plants started exploring the land environment about 400 million years ago, some started the evolution with the advantage of using some of the energy to grow wood that would support the plant's leaves at a higher level. The early woody plants included materials that could not be easily broken down by other organisms. The material that grew in swampy areas was buried in the mud without the carbon being recycled to the atmosphere. Some of this buried carbon would later form fossil fuels. Trees were important for primate evolution and later for construction material and energy.

### *Oil/Coal*

Fossil fuels, such as oil, coal, and natural gas, enabled our transition to an industrial and technological society. However, the formation of these fuels takes special

such as the ability for plant and plankton material to be relatively stable against decomposition before it gets buried and stored. The evolution of difficult to digest woody plants during the Carboniferous period (when the carbon dioxide level started at 8 times today's level) resulted in much of the material being preserved in swamps (during low ocean levels). Eventually, the carbon dioxide level declined, oceans rose, and organisms evolved to decompose wood. However, during this evolution much more organic material survived until it had been buried, as others have called it the Earth's indigestion period. By burying the carbon without oxidizing it (leading to coal formation), the oxygen level in the atmosphere increased. According to the Gaia theory of a self-regulating Earth, this system evolution caused changes in the atmosphere to keep temperature relatively constant despite the increasing energy output of the sun. Later oil formed mostly from plankton debris settling from shallow seas.

### *Flowers*

Most of the plants we see are flowering plants but these were a relatively recent addition to the Earth's array of living species. Before these angiosperms, conifers depended on wind and water to help pollinate and disperse seeds. Flowers occurred on angiosperms, which means encased seed, i.e., a fruit that surrounds the seed. The flower was part of the innovation that encouraged other animals, such as insects, birds, and mammals, to help spread the species leading to greater diversity in more ecological niches. They started replacing the previously existing conifers about 160 million years ago and dominated the land plants sometime between 100 and 60 mya, near the end of the dinosaurs.

### *Grasses*

A suburban lawn is often defined by the quality of its grass. Grasses also supply a large amount of food through grains. What is so special about these simple plants? It actually was a latecomer to the evolutionary scene, first seen about 50 million years ago near the end of the dinosaurs. New biochemical processes (C3 and C4) made them more efficient at converting

sunlight into carbohydrates and sugars. Grazing mammals, such as horses and cows, would eat the top of the grass. If a typical vegetable garden has a rabbit that eats the tops of the vegetables, it is not good for the plants since they grow from the ends sending out new shoots, branches and leaves. Grasses however, grow from the base near the ground, so that a grazing animal does not permanently damage the plant. This is also true for lawn mowers that clip the non-growing top.

Grasses adapted as drier conditions arose to dominate savannahs and prairies that cover about 40% of the Earth's land surface. Grasses also put quite a bit of energy into their seeds. Unlike vegetable and fruits, the seeds of grasses could be more easily stored since they curtail biological activity until the conditions are right. This led many early farmers to work with grasses so that the seeds could be harvested and stored. Part of this grain was used for bread and part for the production of beer (starting about 4,000 years ago) with very similar processes.

## Humans

### *Fireplace*

No one knows how humans first controlled fire, but it was a major step in taking control over environment. Early ancestors of humans (*Homo erectus*) seemed to be controlling fire about a half million years ago, as evidenced by caves in South Africa and China. They were probably familiar with natural fires that occurred across grasslands. Controlled fire gave great advantages. Perhaps motivated by the taste of food scavenged immediately after a wildfire, fire was used to cook food, which performed a difficult part of digestion, thereby allowing more energy resources for the brain. Also, it made food healthier by killing parasites and opening up new food sources such as starches. It could be used for warmth and so enabled groups to live in cooler caves and explore new territories. It was used for security to scare predators away and make better fire-hardened wooden spears. It could be used for light during the night or dark days and facilitated culture by the stories that were told around the fireplace. In addition, maintaining fires required collective action. Later, fire could

be used to clear land for hunting and increasing the land's production. The Midwest prairies are believed to have been formed and maintained by Native Americans using controlled burns (Vale 2002). Later, fire was used quite extensively to process materials such as clay, logs, and metals. We continue to remember the mystery of fire in our houses' fireplaces.

### *Dog*

Dogs were the first domesticated animals, which were originally native ancestral wolves. Living in packs they were naturally social in their packs but not social to humans. This had to be cultivated through a long period as trust through sharing encouraged a selection of genes leading to an animal compatible and beneficial to humans. The benefits included the dogs' ability to help with security, hunting and farming. Dogs were domesticated between 15,000 and 30,000 years ago when humans were still hunter-gatherers. However, unlike the later domesticated animals such as cows, pigs, goats, and sheep, dogs were not domesticated for food or biological materials (such as leather or wool). These later domesticated animals often ate food not directly in conflict with humans, for example grass.

The relationship continued throughout history with social companionship more of a benefit. The domesticated dogs have genetically changed from their ancestors, for example, they can eat more than just meat, enlarging the diet, as compared to the more recently domesticated cats, which still depend on a meat rich diet.

### *Pottery/Brick*

One of the first materials manipulated by humans was pottery and brick made from clay. Clay forms naturally through erosion of silicate materials mixed with some minerals such as aluminum oxide along with trapped (weakly bonded) water. Clay is plastic meaning that it can be shaped without breaking. When heated, the water is driven out and materials in the clay join through sintering. Some ceramic figurines have been found that are about 30,000 years old. However, it was not until humans adopted a sedentary lifestyle, e.g.

farming, that pottery started to be used to store and prepare food. At first the clay was shaped by hand or coiled rolls. Later the potter's wheel was developed in Mesopotamia about 7,000 years ago.

Clay can also be made into bricks that usually include other materials, including stalks or straw, as used about 9,000 years ago in Jericho. Porous bricks can be hardened in the sun. Non-porous bricks require kilns with higher temperatures. An advantage over wood for construction is that it does not burn and is manufactured in small units allowing for flexible designs.

### *Beer/Bread*

Bread and beer seem to have a common history. It is not known which came first but the early Fertile Crescent civilizations had them. Both required milled grain, water, and yeast. In bread, the yeast causes the dough to rise. In beer, the yeast help convert some of the sugars to alcohol. The beer was more of a porridge but it offered a healthier beverage than river water because it had been heated and contained alcohol.

## **Civilization**

### *Alphabet*

One use of clay was to form a binding business contract. Often tokens of items being sold would be placed inside a closed clay container, which was then heated. However, the contract amount, the tokens inside, could not be counted unless the container was broken. This led to symbols on the outside of the container and eventually the tokens were no longer needed leading to a written contract of symbols on the outside between two traders. Writing was also important to convey laws and religious behaviors. Often only the highly trained could interpret these more complex ideas written in code on tablets. While it would be expected that early forms of writing used symbols closely related to the object, this leads to a separation of the spoken word and object, i.e., the symbol does not tell the reader how to pronounce the word, just what it represents. That is a good feature in business where the words for the

object might be quite different. This way a direct symbol for the object can convey meaning between traders with different languages. However, such a system might become cumbersome for more abstract ideas such as found in the law and religions. While the Egyptians formed their hieroglyphics, other civilizations moved to a system where the symbols also related to specific sounds- a phonetic alphabet.

For example, the Phoenicians were one of the first to adapt the symbols as specific sounds and their list of symbols began with the letters alpha and beta. Some of the original objects that the symbols stood for can still be seen. For example, a (or alpha) the first letter of the alphabet, was an upside down capital A, which represented the head and two horns of an ox (alp). The letter M was derived from the word for water (mem) is close to water waves on a pond.

### *Metals*

Clay was just one early material that could be modified by heat. However, clay was brittle, could not be made into sharp weapons, and did not glitter. The discovery of other materials that had these different characteristics, such as metals, enabled a higher level of technology in civilizations. Often the first to discover and exploit the characteristics, for example the Hittites with iron, led them to temporary ascendancy with their technological advantage.

It is not clear how metals were first discovered. Copper, the earliest metal explored, sometimes occurs in metallic form among rocks. Surprisingly, it had a shiny surface and could be formed into many shapes without shattering. At first, the metal was rather rare depending on the natural metallic form. This rareness would lead to status symbols such as jewelry or ornamental and symbolic items. As the material became more abundant, it was used for tools and weapons.

Later more sophisticated combinations of metals led to bronze, where a bit of tin was mixed with copper to form a metallic substance with enhanced properties. Eventually temperatures of controlled fires became higher with ovens and use of charcoal to extract iron from rocks. The iron could be cast, hammered, ex-



tracted to form very durable items. Finer control of its processing started early with a bit of carbon and continues to this day with formulas for special properties based on the trace elements added to iron.

### *Calendar*

The Romans and northern barbarian tribes (such as the Vikings and Germans) fought along the Rhine for control of Europe. The barbarians are often portrayed as backwards but that is often because the Romans wrote the story. The barbarians were often more democratic with less dependence on slavery and military control than was Rome. However, we still marvel at some of the infrastructure that the Romans built with their cities, roads, and aqueducts. While most of us have to travel a good distance to witness these objects, we still see the remnants of Romans and barbarians on our walls in the form of the calendar, specifically the names of the months and days used in the English language.

The name of the first 5 months are based on Roman and Greek gods: Janus, Mars, Aphrodite/Aphrillus, and Maia. The next two are directly from the first Roman leaders Julius Caesar and Caesar Augustus. The remaining months are based on the Latin numerical values that the months once had, although now they are off by two (e.g., our ninth month, September is from the root sept representing 7). Saturday is named after the god (and planet) Saturn. While Monday and Sunday are clearly named after the astronomical objects the moon and sun, the remaining days Tuesday, Wednesday, Thursday, and Friday are named after Norse gods of Tyres, Woden, Thor, and Fyre.

### *Hindu/Arabic Numerals*

We learn arithmetic in elementary school. However, this system took quite a while to develop, only occurring about 1,400 years ago. Previously, arithmetic was difficult, as with the Roman numeral system. However, the system is quite natural in making a mark for each item- a truly one-to-one representation system. Then the number CCXXXI would represent 231 in our system and can be seen as 2(C), 3(X) and 1(I). However,

the number CCI is 2(C) and 1(I). There are no tens. To keep the placement value, a new symbol was needed for zero or nothing. Then this last number can be represented as 2(C),0(X),1(I). Now that there is a place for representing the hundreds, tens, and ones. Those symbols (C, X, and I) can be dropped to form our number 201. This was first documented by the Indian mathematician Brahmagupta in 628 AD. Despite documenting this system, it took about 200 years to diffuse to al-Khwarizmi's Baghdad from India.

It took a couple of attempts and another 150 years to reach Europe when the future Pope Sylvester II unsuccessfully advocated their widespread use. The use in Europe finally started over two centuries later when Fibonacci wrote about them when he was studying in Algeria in 1202. The Italians were interested in how they facilitated banking and trade calculations. This was further spread into Europe by the printing press in the 15<sup>th</sup> century. This illustrates how (what we now consider) a very simple idea, took a long time to develop and a very long time (over a thousand years) to diffuse into widespread common use.

### *Gun*

Guns have a long history evolving through time from a simple bamboo stick filled with rough explosive powder to the advanced machines guns of today. First, an explosive powder needed to be discovered, since simply burning did not develop gases fast enough. What was needed was a set of materials that could liberate oxygen when the temperature rose, forming a very quick self-sustaining rapid energetic release. The Chinese did not know the chemistry at the time but somehow discovered the combination of saltpeter, carbon, and sulfur formed an explosive mixture in the 9<sup>th</sup> century. This was combined with a bamboo tube to form a fire lance, a simple flamethrower in the next century. A sort of cannon developed in the Song Dynasty in 12<sup>th</sup> century, which improved by using metal, tighter fits, and higher nitrate powder. The invention of the cannon might have arrived in Europe a couple hundred years later perhaps along the Silk Road or through Mongol invasions.

The gun, or more explicitly the use of gunpowder,

was revolutionary in social organization. The medieval world of lords and knights, protected in their castles, became obsolete as the walls could be taken down with a few cannon and guns could be deployed without the years of training or expense of maintaining horse-mounted knights. The use of cast and machined iron was also revolutionary. It also led to colonization as one group formed a technological advantage over the other. The colonization also had many consequences such as reported in Jared Diamond's book, *Guns, Germs, and Steel* (1997), in that the many communicable diseases from the Eurasian continent were unintentionally easily spread in the New World.

### *Watch*

Time keeping is fundamental today to not only keep schedules but also to know positions through GPS. However, earlier it was important to monks in monasteries to keep schedules and later by sailors to keep longitudinal position. However, it was a very difficult problem to keep very accurate timing on a ship. John Harrison developed accurate clocks that enabled explorers, like Captain Cook. Watches were first developed with springs but now use quartz crystals, which are also used to synchronize billions of computer operations per second.

However, to get the original accuracy very fine machining had to be done. This same machining also led to scientific instruments such as telescopes and microscopes. The military need for machining cannons led to development of cylinders and pistons for steam engines. Eventually people like Eli Whitney manufactured with machined parts that could be interchangeable.

### *Glasses*

Romans used devices to aid in reading. Muslims advanced optics in the 11<sup>th</sup> century. This knowledge eventually arrived in the 12<sup>th</sup> century Europe after translation in Spain. Eyeglasses were available in the late 13th century. Dutch and Italians improved glass quality in the early 17th century to enable early telescopes and microscopes.

### *Newspaper*

Before newspapers, often the town crier would publicly read important announcements sent by horse or ship. Gutenberg's printing press (1440) offered an alternative but it focused on the higher return from printing books. Strasbourg published a newspaper in 1605. The first newspaper in America was printed in Boston 1690. Ben Franklin started apprenticeship with his brother there in 1718. The mechanical, movable type allowed mass communication but required literacy and challenged control of information.

### *Clothes*

Clothes were invented much earlier in human evolution but are brought up here because of their important role at the beginning of the industrial revolution. The manufacture of cloth and clothes had been a very labor intensive and expensive undertaking. Besides leather, the material for clothes had to be formed from some fiber (e.g., cotton, flax, or wool) into longer threads that were then woven into a two dimensional fabric. That fabric had to be cut and assembled through sewing into clothes for various purposes. The use of mechanical machines powered by water was one of the first steps in the industrial revolution. Richard Arkwright's first water powered mill for producing yarn from cotton was built in 1771. The powered loom was built in 1784 by Edmund Cartwright but required a further half century to make it automatic.

### *Electricity/ light*

Plug a lamp cord into the wall and turn the switch on. Light! While this is just a common experience that very few of us think about (except in a blackout), it is still quite amazing that power is being transmitted from far away over small cables that don't move, to make safe light. This is quite an improvement over most human history when light was either non-existent, too costly, or unsafe. As we've seen before, the fire played a crucial role in human development. While alternative forms of fuel besides wood were identified, such as whale oil and kerosene, these were difficult to obtain, distribute, and safely use. Electricity allowed the conversion of chem-



ical or gravitational (e.g., Niagara Falls) potential energy in one location and its relatively safe and efficient transmission to a city and homes. Power transmission had been done within factories with mechanical belts and pulleys, which required the power source, often a stream or river, to be adjacent.

The discovery and control of the generation, transmission, and use of electricity occurred over a few centuries, starting in the 17th century (with William Gilbert studying magnetism and static electricity) and proceeding through the invention of the battery (about 1800 by Volta), and the electric motor (1821 by Faraday). The invention of the light bulb took many years and many researchers to identify the methods, materials, and processes. Thomas Edison was not the first to discover many of these elements but was able to put them together along with an electricity distribution center (first in New York City to provide a few blocks with direct current) to form a sustainable business model. A great debate ensued over the relative benefits of alternating current (as used today) and direct current (that Edison advocated). Eventually the alternating current won out due to the ease at which its voltage could be changed for transmission. Today the debate continues with the possibility of using high-tech superconducting cables for direct current transmission.

### *Radio*

The transmission of information in almost real time began with the telegraph, using electricity with codes (Morse codes) to transmit information. This was used by Lincoln in the Civil War to communicate with his field generals from Washington DC. A problem with the telegraph, and later the telephone, was that it required expensive wired connections, was easily disrupted, and was not capable of being mobile (e.g. car). While beacons of light had been used since ancient times (and colonial times as in the Boston North Church lights warning of British attack), using light had problems of its own- it was easily blocked so it required large clear distances and required a person to see and interpret the light. While light in the form of optics had been studied long before by Greeks and Arabs and then European for telescopes and microscopes,

it was not until Maxwell in the 1860's formulated a unified theory of electromagnetism. This led to the insight that visible light was just a subset of potential electromagnetic waves, opening the possibility of much greater information and communication capabilities. Maxwell did not live to see their discovery by the German Hertz in the late 1880's. Hertz at the time did not see any practical use for radio waves and would die about 10 years later at age 36, just as others started to put together wireless telegraphy. Radar was later invented and played a crucial role in defending Britain against the German planes in 1940. Now wavelengths all over the spectrum of energies and wavelengths are used in radios, Cell- phones, radar, and microwave ovens. It was a tremendous breakthrough in the ability to send information at the speed of light around the world to be detected amplified and converted into meaningful codes or speech. Now again, much of the information coming into the home is not through radio waves but by optical cables, using the higher frequency of light to carry more information.

### *Car*

The car represents a late second industrial revolution achievement in its use of many materials, requirements for large infrastructure (such as roads, insurance, repair shops, and fueling stations), and manufacturing with distributed supply chains, and continuous incorporation of new technologies such as computers and automation. While some early cars were based on steam engines or electrical batteries, the internal combustion engine won out. It turns out that gasoline has a very high energy density that even advanced batteries today cannot match. The oil industry started in the western Pennsylvania area (Drake's well) and business flourished with John Rockefeller working from Cleveland since Ohio was the Saudi Arabia of the early oil development. Rockefeller was able to refine the crude oil and move it through pipelines safely to overcome his competitors in the robber baron era. Henry Ford in nearby Dearborn Michigan was able to develop a Great Lake port that could easily access materials from all. Iron was supplied mostly from the western parts of Lake Superior in the Minnesota iron ore mines (part

of the banded iron formations mentioned before). The car enabled the development of suburbs as public transit was not sufficient to cover such a wide area. Trucks competed with trains for the transport and distribution of goods.

### *Smart Phone*

The smartphone is one of the crowning achievements of the information age. It offers many functions: wireless and mobile phone; GPS location system to help navigate; Internet connection for just about any information (correct or not) from around the world within a few seconds; and the connection to online shopping to find, order, and have delivered just about anything. This small phone is so powerful partly because of the infrastructure that supports it such as cell towers, the Internet, the people who write and maintain Wikipedia, the GPS satellites, and the manufacturing capability developed over decades of stunning improvements in electronics to integrate what was a supercomputer just a few decades ago into something so slim to fit in a pocket. I am still a bit puzzled at the success of the smartphone and cellular service. I never thought it would catch on and sometimes wish I did not require one for work. The cost of the phone and service is quite expensive compared to the previous technology. However, in some developing countries, the smartphone is able to leapfrog a wired system due to the cost of developing the infrastructure.

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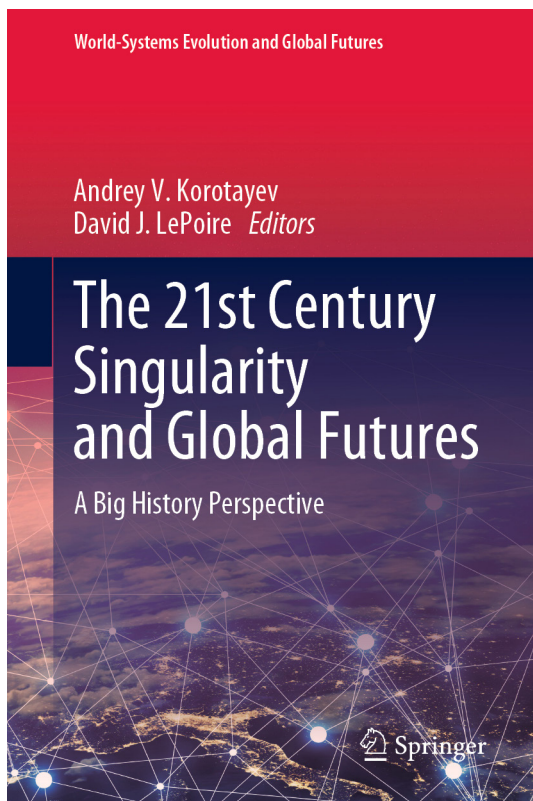
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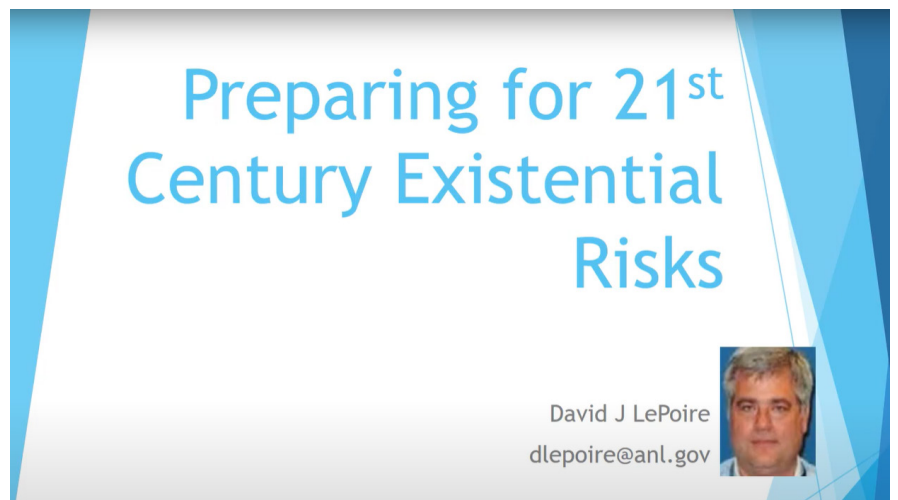
### About the Author

David J. LePoire holds a PhD in Computer Science from DePaul University, Chicago, USA, and a BS in Physics from CalTech. He has worked in environmental and energy areas for many governmental agencies over the past 25 years. Topics include uncertainty techniques, pathway analysis, particle detection tools, and physics-based modeling. He has also investigated historical trends in energy, science, and environmental transitions. His research interests include complex adaptive systems, logistical transitions, the role of energy and environment in history, and the application of new technologies to resolve current energy and environmental issues.

Among his articles are LePoire, David J. 2019. "Size Relationships of Big History Objects: From the Universe to the Atomic Nucleus." *Journal of Big History*, IV (1): 44-48. <http://dx.doi.org/10.22339/jbh.v4i1.4160>. With Andrey V. Korotayev, he co-edited the [\*21st Century Singularity and Global Futures: A Big History Perspective\*](#), Springer. His video on [Preparing for 21st Century Existential Risks](#) is [here](#).



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Visiting Faculty, SSLA,  
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**Dr Afshan Majid**  
Visiting Faculty, SSLA,  
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27 February 2021, Saturday, 3.30 - 5.30 pm IST

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