Part III. BIG HISTORY STUDIES

Exploring Time Patterns in Big History

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Various time patterns in Big History include fractals, waves, cycles, transitions, and singularities. These include a human rest fractal; energy and science learning transitions; cycles in many national histories; accelerating transitions in civilization; a comprehensive evolutionary view; and the possibly unique current situation (singularity) in energy, technology, demographics, and environmental transitions. Possible future extensions in the pattern include a geometric logistic 'Cone.'

Keywords: *risks, singularity, Big History, energy.*

Introduction

Maps, boundaries, names, dates, historical figures, wars, and empires are the things we typically think about when discussing history. However, recent interpretations about emerging historical patterns have led to exciting new potential perspectives. Tools and data revealed many exciting interpretations such as fractal structures in society, technological waves, interconnected transitions, and accelerating change.

These patterns might be emerging behaviors of societies acting as evolving (adaptive) complex dynamic systems. Their evolution involves periodic reorganization, increasing energy use, technological change, and environmental impact mitigation. This view might be extended to a generalized consideration of evolving complex systems to include biological, human, and civilization evolution (LePoire 2020).

This paper explores these ideas and suggests various threads of evidence that may possibly support them. Concepts in the historical patterns include the fractal nature of human rest; the cycles in many national histories; energy and science transitions; and the possibly unique situation we are facing today in energy, technology, and environment. Then the paper continues with a more comprehensive view of evolution through the stages of evolution on Earth including life, humans, and civilizations. This starts with development of models of important historical transitions from hunter-gatherer to today. Then a different way of looking at historical time scales is described. A nonlinear view of history is presented with multiplicative factors of time from the present to the past with the evolution of civilization, humans and life starting approximately five thousand, five million, and five billion years ago. A contrasting view of time from the beginning of the Big Bang is also presented with a much different multiplicative factor.

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Fractal Pattern: Human Scales

Every day many of us engage in about eight hours of official work, eight hours of personal and family time, and then sleep for the remaining eight hours. What changes within a day? Usually not much, but there are two distinct change processes that accumulate and require us to adjust. The first is the very natural aging we all go through – our bodies change along with our relationships and roles in the family and at work. The other process is technological change in areas such as communications, transportation, and entertainment. Often, as we progress through life, the changes are difficult to distinguish. For example, did I get that new assignment because I was now more experienced and mature or was it opened up through new technology that I just recently learned?

Rest is a way to address the stresses of change by recycling and maintaining resources such as muscles, memory, and thoughts. This sequence of human rest periods is roughly one day, seven days, 42 days, one year, seven years, and 50 years. Each subsequent period is about seven times longer than the previous. The fraction of time spent resting starts at 33 per cent but then drops to about six percent for longer periods. The reason for the factor of seven and the six percent fraction of time are not known. This does relate to the fractal formed of gears surrounding a gear of the same size, where each gear is composed of seven smaller ones. The fraction of space of a larger gear not taken up by the seven smaller gears is about 22 per cent between the 33 per cent and 6 per cent. These are like the gears of clock that turn the fundamental ticking into the slower movements of the hands of a clock. A summary of the period durations and percentage of rest is in the following Table 1.

Table 1. The period durations and percentage of rest

Period	Rest Percentage	Basis
Day	33 %	8 hours sleep/ 24 hour day
Week	15 %	1 day of rest per 7 days of official and personal work
Super Month (7 weeks)	10 %	1 four day weekend holiday per 6 weeks (Federal average)
Year	6 %	3 weeks' vacation per year
Mid-life change (7 years)	5 %	Structural unemployment rate between jobs
Life/generation (50 years)	25 % (6 %)	Current U.S. retirement of 20 years (1980-s average retirement fraction in developing countries)
System test (350 years)	10 %	1914–1945; Thirty Years' War

However, what can be said about timescales longer than a human lifespan? About 350 years prior to that, between 1618 and 1648 was the Thirty Years' War where religious strife in Europe saw multiple national civil wars and atrocities in parts of Germany. Prior to that was the Mongol Horde, followed by the Black Death (1349), Viking invasions (865), and the Plague of Justinian (541). A thirty-year transition (definitely not restful but instead a time to question assumptions) would be about ten per cent of the full duration.

Waves: Technologies and Ideas

The next two sections explore dynamics within more abstract technological and idea patterns and then at increasingly larger geographical scales, such as the U.S., Russia and China.

Larger more abstract ideas may show indications of long-term (Marchetti 1980). Technologies, energy, economics, and worldviews (religions) are compared to discover patterns. About every 100 years since the scientific revolution, both the technological basis and the global center of political leadership have shifted (LePoire 2010b). These transition waves help set the context of social dynamics (demographic, democratic, and developmental transitions) analogous to surfing ocean waves (LePoire 2009).

Energy

Since the ability to capture and effectively use energy drives change in ecosystems, human communities, and civilizations, the historical dynamics of energy use might indicate approaches to further understanding (Smil 1994, 2010). For example, the major event of humans gaining control of fire created significant possibilities to increase energy flow from a non-food resource.

Energy use changed over history in both the type and amount of primary fuel consumed. Besides using muscle and domesticated animals, humans have used various primary energy fuels such as wood, wind, water, coal, oil, and nuclear power to support transitions to more complex levels. These transitions included the complex organization for hunting and gathering tribes, agricultural villages, civilized states, trading networks, and industrialization.

The increase in energy usage over this period is illuminating: a human's intake of 2,500 calories per day corresponds or averages to about 100 watts (W) (*i.e.*, about as much energy as a large incandescent lightbulb uses). The average current per capita rate of energy use in the United States stands at 15 kilowatts (kW) of energy (including commercial, industrial, and residential use), or about the energy that 150 people would need.

Wavelike patterns in the world's mix of primary energy sources since 1850 were identified in the mid-1970s. The model accounted for the shifts in primary energy use from the mid-1800s when wood was primarily used, through the late 1800s, when coal use climbed, through the early part of the twentieth century, where oil became predominant and uses of natural gas and nuclear power rose. The actual use of primary energy sources during this period has shown deviations from these predictions, in that the relative fractions of the primary energy sources were stable since 1980. During this period, total energy demand rose substantially, but the contributions from each primary energy source kept pace. An extended substitution model including efficiency explained these deviations (LePoire 2004).

Transitions of Western Leadership

One of the strangest twists in history was the emergence of the industrial revolution in Europe instead of China, which had led technically and economically for centuries. A recent analysis by Jack Goldstone (2009) recognized a series of factors that were different in the European experience.

The variety of sizes of countries in Europe allowed nations to experiment with government and economic forms. Some organizational innovations led to continued growth in trade and naval power to protect it. The sequence started with the explorations of Portugal, motivated by the loss of Constantinople in 1453 to find alternative routes to the profitable Eastern spice routes. However, they were not able to connect to a sustainable economic system.

Instead, the Netherlands fought to gain independence from Spain in the late 1500s. The Dutch were able to combine trade in bulk goods, such as timber and herring, with naval power and innovations (in shipping, commerce, and capital) to reach its 'Golden Age' in the seventeenth century (about 1585–1685). This started a sequence of leading countries in the West, which was followed by England (after the Anglo-Dutch trade wars) and then the United States after the World Wars. This leadership sequence, with transitions about every 100 years, moved to ever-larger populations, perhaps because larger states have the flexibility to develop more complex organizational processes and adapt to new technology (LePoire 2010b).

This pattern suggests that the succeeding leader has an initial population that is about twice the population of the preceding leader at the transition. If this pattern continues, a transition of leadership to a country of one billion would be expected followed by a transition about a century later to encompass the global population.

Exploring Worldview Historical Transitions

Are there patterns such as cycles in major worldviews or religions? There are three aspects to explore: 1) the wavelike behavior of historical growth in one religion (*e.g.*, rates of sainthood and cathedral construction) (Marchetti 1980); 2) the sequence of events that lead to a fracturing of a religion (*e.g.*, the reformation); and 3) the interaction of two major religions leading to cyclical shifts in leadership (*e.g.*, Islam and Christianity).

Many complex systems exhibit patterns such as splitting (bifurcation) as the system progresses. An analogy might be a glass window a single crack that later expands and splits untie the full pane shatters. The Protestant Reformation was a major split in the Christian religion. However, this was a culminating event of a long pattern of splitting since Roman Emperor Constantine accepted tolerance of the Catholic Church in 313. The rate of major divisions in the Catholic Church started about 750 years after this unification, but proceeded then at an ever-increasing pace with each division occurring in about half the time.

A sequence of five further divisive events ended with devastating Thirty Years' War over religious rights. These divisive events include the East-West Schism between the Roman Catholic and Eastern Orthodox split in 1054; the Western Schism in 1378 when differences between religious and secular authority resulted in two separate claims of the papacy; Luther's Reformation (1517); the Dutch independence from Spain (1609), and the Thirty Years' War which ended in 1648. The splits in the church seemed to accelerate with almost a doubling of time between the splits: 750, 324, 139, 92, and 39 years.

Fundamental Physics Discoveries

Does science develop faster as more is known? Or are scientific fields developed slowly at first as definitions are determined, then at a relatively constant rate with well-defined issues, and then again at a slower pace as the remaining issues require resolution under greater consistency constraints? A set of data that might help address these questions is the source for much of the technological advance, fundamental physics (see Fig. 1) (LePoire 2005).

Symmetry of the curve would have three stages beyond (HEP, string physics, and another yet unidentified stage) the center stage to match the three stages before the center stage. The transition width, *i.e.* the duration to go from 20 per cent complete to 80 per cent complete is 212 years. If the logistic interpretation is continues, the data suggest that string physics is likely to be 50 per cent complete in 2030 and 80 per cent complete in 2090. Another stage might develop after string physics, which, if symmetry holds, would have 20 per cent, 50 per cent, and 80 per cent completion times at 2100, 2180, and 2260.

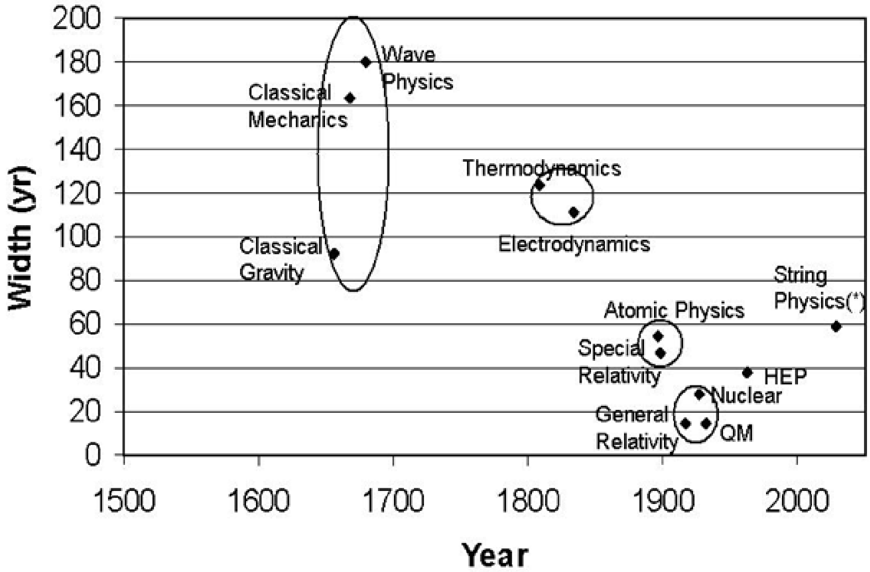

Fig. 1. Graph of the characteristic time (20 % to 80 % completion time) versus the year of median (50 %) completion for the 11 subfields. The circles show the groupings of subfields with similar median completion times into stages. Note that the right-most point (string physics) is just an estimate

National Dynamics

In an earlier section, temporal patterns were identified in the human rest cycles. How does this pattern connect to the scale of a country? Does it extend to longer time periods (Modelski 1987a, 1987b)? To address this, the current oscillations in the U.S. political cycle will be explored and compared to navigating a sailboat tacking against the wind (LePoire 2009). The pattern of eight years of one party's leadership followed by eight years of the other party has proceeded since the end of World War II (76 years) with just one four-year exception (see Fig. 2).

A longer pattern of 72-year periods is then explored based on the sequence of great presidents who addressed large questions in the country's development. This pattern goes back to George Washington with about four full cycles. Then the pattern continues through the western world history with a cycle of about 350 years.

Finally, we search for this longer pattern in Russian and Chinese histories. Each country has its own distinct feature compared to U.S. and the West: Russia seems like a mirror reflection of the U.S. both geographically and historically (LePoire 2008); whereas China has evolved in a rather stable location in contrast to the moving center of Western leadership.

Many have addressed cycles of both political and economic waves, such as Kondratieff Waves. The fundamental cycles seem to occur about every 72 years (about a human lifetime). Each cycle seems to have a crisis event.

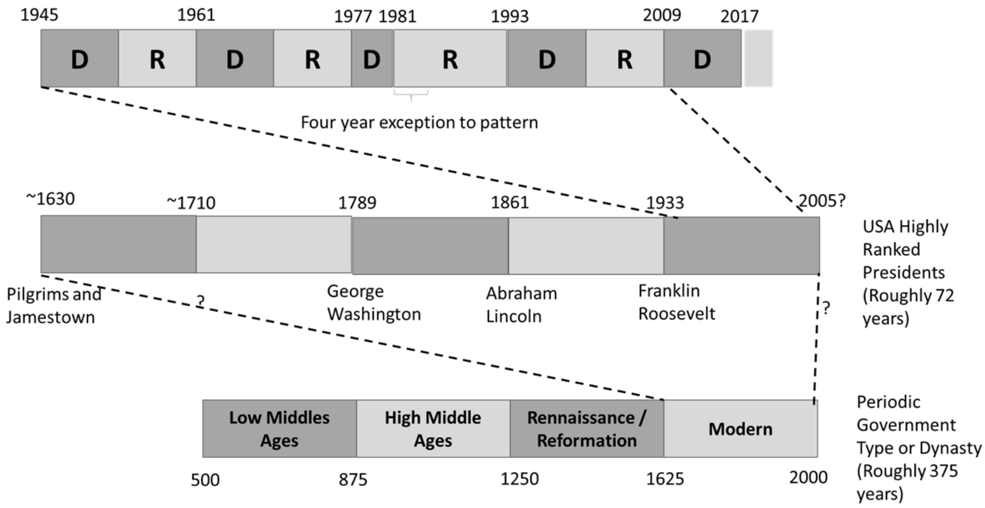

Fig. 2. Three cycles with increasingly longer periods. Top: periodic political party cycles with 16 year period (D= Democratic party, R= Republican party). Middle: phases of U.S. development separated by important leaders. Bottom: classical Western historical ages

Each of the three countries, the U.S., Russia, and China, has a unique history and geography, which can be compared and contrasted. Russia started on the eastern border of Europe, which came under a series of invasions. The relatively young U.S. started as a European colony to the west, which incorporated many waves of immigrants. China maintained national identity with the longest history of leadership but western influences eventually punctuated the technological and political leadership. However, China seems to be on a course to merge both Eastern and Western aspects to a new leadership position.

This Western European Cycle was compared to dynasties in Russia, and China with periods of about 375 years identified in each (see Fig. 3). Russia and China had two major dynasties within each 375-year period. In Russia, the relative durations of the two dynasties changed with time. In China there seemed to be one major dynasty along with a relatively shorter period of transition, which might include a chaotic state.

Historical Major Transitions in Civilization

Various qualitative models have been suggested for major historical social and technological transitions (Bernstein 2004; Diamond 1997). Many of these transitions still have puzzling aspects such as the early transition from hunter-gatherer to agriculturally based society, which required dramatically increased effort.

Many types of models could be applied to these transitions. First, basic characteristics, such as width and midpoint of the transitions, are determined by analyzing historical events contributing to the transition. However, this does give much insight into the dynamics or parameters of the transition. For more understanding, each of the six transitions was explored with a simple phenomenological model. These simplified models do not attempt to address quantitative details of the actual historical mechanisms. Instead, analogies to more natural systems are invoked to gain insights (LePoire 2019).

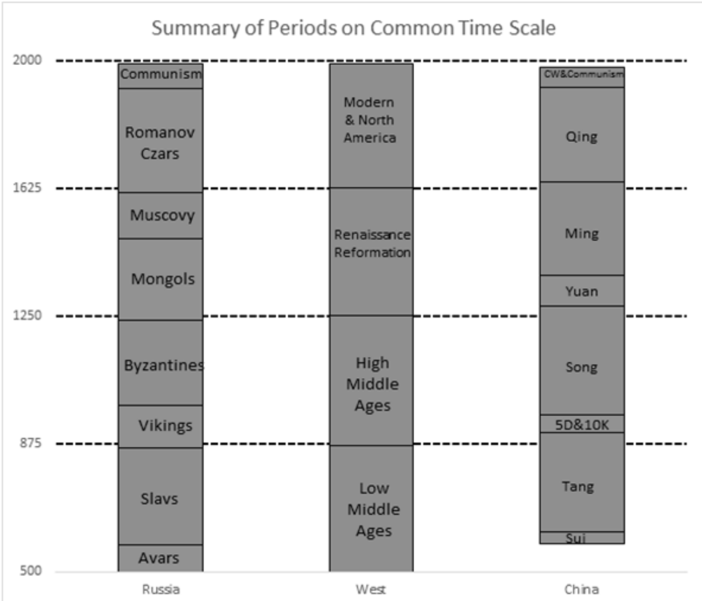

Fig. 3. A summary of the sequential periods for Russia, the West, and China

Singularity: Extended Evolution

Big History can be described with four major evolutionary phases (Chaisson 2004; Sagan 1977; LePoire 2016). These are development of the Cosmos from the Big Bang to the formation of the Earth, the evolution of life on the Earth, human evolution, and civilization (Christian, Stokes Brown, and Benjamin 2014). The last three phases had different ways to process information in adapting to their environments – DNA for life, human brains, and writing.

Carl Sagan (1977) pointed out that there were information limits with each system. As one information system reached a limit to further adaptation, a new one would develop to enhance capabilities. For example, after a variety of life expanded around the world into different ecosystems in oceans and on land, the mechanisms of DNA evolution were inadequate to match the higher level of competition between mammals. Now, we might be approaching another limit of writing to support our organizations as the globe becomes more interconnected with resources, energy, health, environment, and protection.

One interpretation of Big History is that three major evolutionary stages discussed before – life, humans, and civilization, formed the first half of a transition. This learning curve is a bit different as it is formed from many smaller transitions and also changes (learns) at an accelerating rate as it approaches the current time, near middle of the transition. These three major stages started at about five billion, five million, and five thousand years ago. (As mentioned before, while more precise times are known for the beginning of the Universe at 13.8 billion years ago, and the formation of the Earth at 4.54 billion years ago, this book works with geometric factors, so an approximation on a logarithmic scale is used.)

This evolution of increasing complexity seems to go against the natural flow toward randomness from the second law of thermodynamics. This is possible only because the Earth is not a closed system; it experiences a net flow of energy from the Sun. The difference between high-energy light coming from the sun compared to the low-energy (infrared) light leaving the Earth causes an energy flow. Similar flows are generated with temperature gradients, for example at the bottom and the top of a boiling pot. However, these energy flows can contribute to pattern formations that actually increase the flow of entropy (Bejan and Zane 2012; Schneider and Kay 1994) (as with the columnar rolls in a heated pot).

What are the dynamics within these steps (Jantsch 1980)? The dynamics of a system exploring a new environmental niche is at first rather rapid growth while utilizing newly identified resources and enabled by the new application of information in an innovative coordinated system (*i.e.*, organization) (Morowitz 2004). The system generates an increased energy flow (Chaisson 2004; Niele 2005; Fox 1988) to mitigate effects of the natural tendency towards chaos (entropy). As the system grows, new environmental impacts due to increased energy flow are no longer easily handled (Ponting 2007; LePoire 2010a, 2006).

To gain a perspective on these factors, if the time values of the three major stages are plotted on a line (*i.e.*, five billion five million, five thousand) with the line being one kilometer long which represents the age of the Earth, then the development of humans would start at one meter from the end. All of written civilization history would occur in the last one millimeter. If the time between the Big Bang and Earth formation were added, the line would be about three kilometers. A human generation scale of 50 years would be ten micrometers, less than the width of a hair.

The Inflection Region or Singularity and Beyond

These trends of life's accelerating increase in complexity throughout its history on the Earth suggests that a unique time (a unique or singular event, *i.e.* the singularity) might be realized soon (Modis 2002; Kremer 1993; Korotayev and LePoire 2020). At this unique time the growth trend might display unusual behavior. Debate continues whether the rate of change at the singularity will further accelerate, slow down, or demonstrate other behavior (*e.g.*, flattening, collapse). Very basic questions about this historical trend concerns the causes such as mathematical conditions of growth and factors like energy, environment, and information. Further details include determination of indications of the singularity's behavior (*e.g.*, time, number, type) and the pattern of substructure (*e.g.*, timing, transition characteristics) leading up to the singularity.

How we might know?

In history, there can be many levels of addressing the question 'Why?' While at the detailed level are the actual events and people, other reasons might gleaned from more abstract levels. This includes the connection of energy and environment to continuing further evolution. Each phase of history improves energy flow to advance to the next phase. This requires a sequence of learning periods to extract, use, and handle the environmental impacts of the energy source.

The debate concerning these abstract interpretations of historical events are likely to continue. Some questions to explore include the continuation of the patterns, the rate of technological change (slowing or accelerating), comparison to other systems and models, and further development of theoretical and empirical evidence for or against patterns of the universe's complexity development. This evidence involves aspects of evolution, reorganizations, energy use, emergent characteristics, and geometrical scaling factors.

As the metaphor of rocketing into sustainability will illustrate, the current situation (with a temporary set of technologies and lifestyles) is fleeting until limits to the systems are hopefully resolved to enable continuation of this great experiment.

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