The History of Thought, Book 2

The Co-Evolution of Technology and Cognition in Human Species

Summary:

History of Thought, Book 2: The Co-evolution of Technology and Cognition in the Human Species, will follow a similar approach to Book 1, but proceed from a time about 8-12 million years ago to the present. Given the extinct nature of most of these species, this second book will feature some different tools and methodologies than Volume 1, but a similar comprehensive synthesis of multiple disciplines into a single survey. This book will be co-authored by one of the authors of Volume 1, Pat Scannell (technologist), as well as Tim Taylor. Taylor is an archeologist with a background in biological anthropology and cultural anthropology. He is Professor of Prehistory of Humanity at the University of Vienna, Editor-in-Chief at the Journal of World Prehistory, and author of several books on human prehistory.

Uses a diverse range of fields, including Evolutionary Psychology and cognitive archaeology, to ethnographic analogy (with all of its advantages and dangers) to modern day genetics and sociology. Examines thought from a variety of perspectives including what people thought about, and how they did that thinking.

Notes that much of thinking is a reflexive reaction to one of the four realms we identify below (Society and Culture; Technology; Biology, cognition, and intelligence; and Language). Meta-level exposition provides an ability to understand the multiple different kinds of human thinking, much of which passes unnoticed and unexamined in modern day to day life.

Chapter 1 Introduction

Establishes prominence of "protohumans" in current evolutionary psychology and other fields; notes that there is dramatically less evidence to work with here than with extant primates. Also note that the prominent current theories don't often acknowledge that many of the human traits are built on the cognitive foundations built up in earlier primates. There are 2 key gaps in the literature: integrating the primate literature of 60 mya-~6 mya with the "early human" scholarship of the last few million years; and a deep dive into Wilson' "Stone Age emotions", in a way that integrates it with the modern mind and technological innovation.

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- Sample chapter observation: Note no single attribute or technique that caused *Homo sapiens* to thrive: an accumulation of cognitive tendencies (pro-sociality, abstract thinking, pre-planning, Theory of Mind, Enquist et al The Human Evolutionary Transition, etc), subtle changes to physical capabilities that unlocked enhanced facial expressions, language, versatile physical makeup (movement, environmental adaptation, diet), and sophisticated social structures. Technology (language, trading, art, ritual, clothing) did not arise on its own, autonomously; it arose from accumulation of characteristics of human cognition and behavior. Successful techniques and technology had a positive bootstrapping effect on unlocking or the accumulation of other technological areas.
- Present relevance: Technology in the modern context doesn't self-augment, autonomously. At least not at scale, yet. It arises as a direct result from human activity, largely in anticipation of or in response to human's needs or wants.

Chapter 2 On the "primate brain"

Short chapter, summarizing Volume 1: Recap how primates differ in biology and behavior from other mammals, the concept of brain size vs EQ, gross brain anatomy, review of primates' primary senses, the concepts of social systems and life history. Primates' evolution from tree-dwelling, insect-eating ancestors results in high brain/body mass ratios and also high energy rate density of the brain. The highly modularized and mostly unconscious cognitive functions that regulate survival through drives like "fight or flight" responses, mating. Reviews how primates communicate, and the fact that primates have far more than 5 senses. Summarize how the factors above yield primates' techniques for interacting with the world (with limited innovation), and what factors affect how techniques diffuse within social groups, and even across different cultures within a population. Cognitive features of primate brain. The evolution of the primate brain characteristics, and the technological changes associated with each. Share conclusion that it is these factors, as much as any that has evolved in the last 300,000 years, that still shape our modern-day technology. Note the length of time between primate evolutions, and the short period of time humans have been on earth.

Chapter 3 Protohumans

Reviews 6 species of "ground apes" (Ouranopithecus to Ardipithecus), and the Australopithecines. Uses the perspectives of:

- Society and Culture (e.g.: the inherited background (vide Vol 1):early hominins as a continuation of social learning systems in higher mammals)
- Technology: the emergence of distinctive 'material culture', and 'material cultures': hand-eye coordination; manual dexterity and its extension; semiotics of environmental modification: artificials and the recognition of artificials as an index of competitive presence; expedience over entailment
- Biology, cognition, and intelligence I: food sources, energy, altriciality/ontogenic retardation; amrine resources, shortened guts, fire.
- Language (spoken): Greenberg hypothesis: linguistic problems; Marr; Sapir-Whorf; vs Chomsky & Pinker

Discuss the techniques of studying long extinct species including archeological (e.g. the total number of bone fragments from many of the early species would fit, together, in a large shoebox), carbon isotope analysis (e.g. dietary composition), and various new genetic analyses (e.g. understanding the genetic mutation of the ADH4, perhaps ~10mya, and how human's relatively unique ability to process alcohol can be traced to this period).

Discussion of geographic distribution, and methodologies used to study sites where these remains were found. Migrations, probably a result of climactic swings, and or other environmental forces. Adaptations to ground living (while likely still sleeping in trees), and how ground foraging helped to select towards "upright", as preadaptation to bipedalism. Review of common causes of death, including predators (and defenses). Diet flexibility. How these factors lead to LCA/chimps & first protohuman; when, where and why.

Overlooked pre-adaptions – carrying, possible effects on social structures, characteristics/life histories.

- Rapid speciation: evolution by basin, selection for hominid adaptability, which in turn, leads to hyper-speciation (relative to earlier primates)

- Opposable thumbs
- Sticks as tuber-digging and spear use
- Pre-adaptations for brain re-organization

Establish connections between enhanced diet and enhanced cognition. Higher cognitive demands of increasing social complexity.

- Sample chapter observation: Punctuated equilibrium leading to multiple approaches solving ecological niche; specialization loses out to adaptability
- Present relevance: talk about present as unique point in time, and the case for similar punctuated equilibrium. Won't lead to speciation (timeframes too short, lack of reproductive isolation, lack of selection pressures), but likely to lead to various significant new adaptations, behavioral and otherwise.

Chapter 4 *Homo*

Reviews current understanding of the various species of genus *Homo*. Significant increase in brain size, and the theories to explain, including meat-eating, complexity of foraging, response to changing environment, genetic mutations, and a positive-feedback loop of innovation. Other key traits and techniques include body changes (including dimorphic trends, and the implications), with species gradually becoming taller, thinner, and able to walk and run more efficiently, including, when taken together with the evolution of our unique naked skin, a notably ability to shed heat. Explanations for the advantages of bipedalism (including increased energy efficiency in foraging), and environments in which these features arose; touch on implications, brain re-organization, life histories, brain growth, changing diets. Review of common causes of death, including predators (and defenses). Changing skull and pelvic structure in females imply evolving life histories and secondary altricialty (the extended period in which human offspring are incapable, and dependent on others, and during which there is considerable brain growth and maturation; unique to humans), and the Neandertal brain size being larger than *Homo sapiens* provides an opportunity to discuss the 'obstetric dilemma' of large brains. Broader shoulders and changing shoulder sockets, often associated with humans' unique ability to throw.

Uses the perspectives of:

- Society and Culture II: the affordances of environments and materials; the creation of nested environments; Gravettians and distance calculation; season recognition without calculation or counting; the problem of subitation
- Technology II: the emergence of innovation as a value (creating insulation for experiment); the Out of Africa expansions; Neanderthals, Denisovans and moderns: territorial, physical and cognitive competition; society as the fitness environment (sexual selection and intelligence II)
- Biology, cognition, and intelligence II: the recognition of environment-specific skill sets; inter-group arms races (competition and genocide); inter-group predation.
- Language II: the emergence of material symboling systems; symbolic and symboling cultures: Early cosmological concepts among *Homo sapiens*

Tool use increasingly common, and increasingly sophisticated. Complexity and layered techniques of tool use, including tool kits as a case study in technology. Diet increasingly of meat and use of tools to gain access to food extraction not available to other animals. Adaptability gains of these techniques, especially during periods of scarcity including the hypothesis that humans leveraged their resources to outperform other scavengers. Cognitive consequences of eating more meat. Technique of sleeping on the ground, and the consequences are reviewed. The spread of *Homo* outside of Africa, including the proximate causes, consequences, and enabling techniques. For example, throwing is an advantageous technique in new ecological niches, and there is interdependence between advances in Acheulean stone tools techniques and hardwired neural circuitry required to throw effectively. Note changes in climate at 2.8, 1.7, and 1.0 million years ago correlate well with observed transitions between recognized hominin species.

Increased use of fire, examined from both a technique (make, carry, control, use), as well as a near term consequence (fire provides increased ability to store meat, make certain inedible foods edible, and thereby expanding food sources, aid in making other tools, and fire as a factor in enabling predator safety). Fire serving in its various capacities to essentially double the energy rate consumption. Long term consequence of fire as being a pre-condition to humans developing a "home base", which is a pre-condition for later horticulture, and even social bonding. This chapter examines the theories and evidence that artistic concepts developed much earlier than previously believed. Introduce concept of cultural intelligence.

Re-organization of the brain documented, with interdependency of increased tool use, handedness, and lateralization of the brain is closely related with the neural changes that language will depend on. (Each new technology is built on the cognitive architecture of the old and contains the seeds of the next). Also discuss other genetic evidence and anatomical speech pre-adaptations. Informed speculation re: evolving social structures and behaviors including gender roles, pro-sociality (including altruism) and 'grandmother hypothesis'.

- Sample chapter observation: Overlooked technical innovation of transition to ground sleep and likely effects on cognitive development, in part through likely changes in REM sleep.
- Present relevance: changes in human sleep patterns brought about by technologies like electricity, and now changing digital entertainment and other electronic devices. How new IOT biometric technologies can monitor and even aid us in optimizing our sleep, through biofeedback and other techniques.

Chapter 5 birth of *Homo sapiens*

Considers circumstances around emergence of first *Homo sapiens*, ~300 kya, in northwest Africa. Current research, genetic admixture, evolving taxonomical debates, timing, climactic pressures, and views on immediate ancestor(s). Physical evolutions that characterize "anatomically modern *Homo sapiens*", relatively "gracile" compared to prior species, and how associated with increased adaptability and behavioral changes, including enhanced technology use and social coordination. Introduce introgression (re: Neanderthal, Denisovan and other genes). Note co-evolution of facial changes with cognitive processes that unconsciously process and interpret facial emotions (e.g. eye saccades and related visual circuits), along with increased Theory of Mind and pro-sociality. Top-down and bottom-up attentional orientations, focalization and allocation of resources.

Uses the perspectives of:

- Society and Culture III: Global changes in MIS 3 and MIS 2: the pre conditions for farming and domestication; a new semiotics of death.

- Technology III: the emergence of the built environment; land ownership and long-term investment; genealogies; number and measure; pyrotechnological elaboration; entailment over expedience.

- Biology, cognition, and intelligence III: demic diffusion, birth spacing; dietary fitness; social hierarchies; zoonotic pressures

- Language III: Babel: weaponized languages; norms and sanctions; us and them; ritual languages and mortality as a concept

Review important cognitive changes -brain size, organization, cytoarchitectural and other neurological differences, including changes in key brain metabolic and other biological functions) present in *Homo sapiens*, but not found in other extant primate species, that helped support enhanced cognition and adaptability. Discuss Enquist's theory of human evolutionary transition.

Review, briefly, *Homo sapiens'* current brain, with functional description, architecture, and performance quantification: current estimates (with uncertainty, since these are notoriously hard to count given their complexity) that it is composed of about 86 billion neurons. Note possibility of quantum function. While our conscious thought is what we are most proud of, especially our higher order thinking of the prefrontal lobe functions, it represents just a small slice of the amazing asset that is our brain. And, relative to the rest of the brain and to computers, these conscious processes are quite limited, and highly dependent on the underlying processes – not just to stay alive, but also to process information somewhat efficiently.

Notes evolution's efficiency, and how all of that processing power was adaptive and required to help *Homo sapiens* survive and thrive in their environmental niche, and in the rapid and complex global human population dispersal, and corresponding climactic factors. Compare/contrast techniques/technology of anatomically modern *Homo sapiens* (amHs) with prior species (increased use of fire, tool kits, organized hunting, tool complexity, long distance trade). Pro-social behavioral traits, including altruism and the technique of coordination (even and perhaps especially and uniquely, among strangers). Review of common causes of death, including predators (and defenses). Notes that rather than any specific specializations, sapiens have generalized overall advantages in adaptability and versatility, relative to prior species. Ability to navigate around genetic dead-end streets of specialization.

Discuss the interactions between the multiple human species living on the earth simultaneously, as well as their effects on other megafauna.

Reviews major changes in human condition from amHS to "behaviorally modern *Homo sapiens*" (bmHs), such as advent of language, complex tools, symbolism/art/ritual, writing. Shifts from "tool using" to "complex tool making". Summarize the current thinking about the geographical and temporal transition and distribution of the modern behaviors, and proximate causes, including theories of climatic change and population bottlenecks (e.g. Toba and others). Propose theory that modern behavior is a natural "accumulation" or technological acceleration that occurs, given the cognitive capacity of humans, much like Dawkins view that large brains boot-strapped themselves. I.e. a technique that increases productivity creates a new surplus, within which there are the seeds of the opportunity to invest in the development of other new techniques, and so on. <u>*How humans harvest the returns of any new technology dictate the speed at which technology accretes.*</u>

Discuss hypothesis that people were proto-domesticating their lands, prey, and grown foods long before they came together at scale as the technology we now consider "agriculture".

- <u>Sample chapter observation</u>: Language was a "new software" developed and laid down over a substrate of "existing hardware", with significant implications, but requiring significant co-evolutionary factors.

- <u>Present relevance</u>: Modern digital information, primarily characterized by a rise of digital entertainment, itself targeted to anachronistic attentional biases, has the potential to be a negative feedback loop that "rewires" how individuals and groups think, with effects as powerful as the emergence of language. But the digital revolution is happening far faster, and geographically far broader, than the original emergence of language.

<u>Chapter 6: birth of Agriculture (mini-chapter):</u>

Agriculture as just one form of domestication, and in terms of land use the distinctions between horticulture, pastoralism, and arable farming. Discuss dynamics, pacing and attributes of domestication, using grains and animals, including paedomorphism. Attributes that lend species to domestication, and review of hybridization and introgression in this context. Review of domestication of dogs, foxes, cattle, and the self-domestication theory. Review net energy yields as a result of foraging, versus hunting, versus techniques associated with agriculture, and how all vary across a variety of environments. Environmental, mechanical, nutritional, behavioral, energetic differences between C3 versus C4 foods. Introduce the theory of human self-domestication.

Examine pre-agricultural settlements of 19kya-14kya where partial agricultural techniques adopted. Increased specialization of tasks, more formalized social hierarchies, the beginnings of property rights, changing gender and child roles (techniques that were pre-adaptations for later civilization). Interdependencies of new techniques (agriculture leads to stored food, leads to property rights and inheritance, which changes consequences for mating and other social factors). Labor intensive agriculture and food surplus now places a premium on more children, a driver/ratchet to population increases. Association between increasing agriculture technology and delayed childhood maturation. Note climate change of Younger Dryas (12.8kya), and association with first fully agricultural sites, that arose, independently, at least 11 times across the world, between 11 kya and 5 kya. Cover techniques and technology of animal domestication, and consequences, including the Oxen Hypothesis, where growth of agriculture was accelerated greatly starting ~6kya where oxen were domesticated. This decoupling of labor and wealth created a bootstrapping effect similar to modern day economies wherein the more oxen you had, the larger your farm; the larger your farm, the more oxen you could own.

Cognitive implications of farming –from the different cognitive demands of foraging versus farming, impact of changing diet on cognition, to the conceptual implications of risk-taking and forward-thinking investment. The birth of both entrepreneurism and 'worry'. Competing viewpoints on the consequences for agriculture. On one hand it is an enabling technology that pre-conditions human social groups for subsequent transitions to civilizations. On the other, associated with changing inequalities in social structure, rise of disease, a decline in a number of human value categories over hunter/gatherer or nomadic lifestyles, and the early evidence of mass murders. Discussion of changing causes of mortality.

Use agriculture as a case study for the ratchet effect of technology, but unlike the consolidation of techniques into the technology of robust language, the evidence of how techniques combine into the technology of agriculture are around us today. We can see how farming is composed of breeding, propagation, crop protection, harvesting, and food storage. Each technique can be used by itself to improve resource productivity, and as the techniques combine, there is emergent value. This additional emergent surplus is a resource and incentive to promote new innovation, and adoption of new techniques. Through this positive feedback loop example, we can see the complex nature of the new innovations; a positive sum game, creating an ever-quickening cycle which has *<u>delayed and accumulating</u>* positive and negative consequences; introduce sigmoidal growth curve for the first time. The difficulty of predicting the consequences. We can also examine lock-in, and understand why, after such a technological process begins, it is sometimes hard or even impossible to unwind. A dynamic that looks like technology is autonomous and self-augmenting; but is not.

- Sample chapter observation: ratchet effect of combining techniques into the technology of agriculture
- Present relevance: Note the rapid pace of introduction of the key transformative technologies today across a range of domains: Internet, smartphones, Internet of Things, 5G (all of which are general) but also in industry specific breakthroughs like 3D printing, improved material science, better engineering, rapidly evolving medicine, improved energy systems. Note that the positive feedback loops both within and between each of these innovation streams, which will continue to accrue and even accelerate over time. As such the advantages and negative impacts are hard to understand at the point of innovation, at the bottom of the s curve, as we have limited ability to predict complex emergent behaviors when we change multiple factors at once, in open systems. This stacking of sigmoidal curves, and the emergent value that arises from the complex interactions between them, is the basis for "algorithmic" pace of change today.

Chapter 7: Civilizations I

Survey necessary pre-conditions of techniques and technologies required for civilization (e.g. tool use, language, agriculture), the pre-adaptive techniques spawned from agriculture (e.g. -food surpluses, specialization of roles, increases in other specialized resource extraction/production, changes in social structure and life history, property rights, long distance trade, more formal social hierarchies).

Uses the perspectives of:

- Society and Culture IV: The rise of the city state: from multiplex to monoplex relationships

- Technology IV: metals and mining; the emergence of the Bronze Age World system; from reciprocity to markets; from social credit to calculated debt and interest. Future-oriented calculation of advantage. Boundaries, walls, and zones. Concept of 'natural' technological change down generations rather than fixity

- Biology, cognition, and intelligence IV: standard differential access to realms of knowledge; divergence in learning opportunities (zonation, professionalization, guilds and esoteric knowledge)

- Language IV emergence of writing and calculation systems as elite control mechanisms: von Humbold; Childe; Andren.

Spend time on the scaling of "crafts/trades". Trace roots of skilled production back to early stone tool production of >2 mya, note the rapid increase and diversification of crafts and trades during the periods after farming lead to permanent settlements. Emergence and roles of guilds, in both growing and limiting the diffusion of techniques. Importance of less heralded inventions such as the screw, lathe, and water mill on subsequent technology. Rise of pottery to transport and store grains. Metalworking as a technology case study for how, like farming, multiple techniques (resource extraction, refining, production, and, often: trade), but unlike farming, the sub techniques of metal working technology are of lesser value, unless there is trade between social groups. Detail development of key techniques and technology in the development of textiles, metal working including the advances from bronze to iron (and the key precipitating factors and techniques), pottery, wheels, and glass. "Unheralded" breakthroughs, such as the windmill and the horse collar (which unlocked breakthroughs in both agriculture and transportation).

Population trends, both in individual locations (especially relevant as social groups grow beyond the "Dunbar threshold" of 150 individuals), and worldwide, as human populations begin to climb rapidly. Diamond's 5 factors (environmental damage, climate change, hostile neighbors, and friendly trade partners, societal response to environmental factors) and his conclusion that civilizations collapse by when they ignore the last factor, and Toynbee's 2 (creativity and will to overcome), and his conclusion that civilizations collapse when the public support wanes for "creative minorities". Increase in geographic footprint, and changes in environmental adaptations. Climate changes during the rise of civilizations: note Medieval Warm Period of c. 950 to c. 1250, and The Little Ice Age from c. 1300-c. 1850 (with peaks at 1650, 1770, and 1850). Human responses to climate change, including technical and technological consequences. The role of technology as a contributing factor to the depopulation effects of war, famine and plaque, and subsequent effects on technology. Mumford's theory of war as chilling effect on invention.

Changing roles of culture, in the form of the shared symbolic - of laws, art, politics, myth, ritual, and religion. Note how patrilocal tendencies caused women, in particular, to be the vectors for cultural and technical diffusion (e.g. Egtved Girl). Changing roles of social group identification. Religion as an organizing factor. Discuss specific technology of governing growing populations (e.g. technocracies and technopolies; Mumford's "mega-machines", the monopolization of power). Diffusion and evolution of these meta-technologies, across time and geography, and key enabling factors. Competition between civilization, in trade, war and culture, as a factor motivating new innovations. Note the individual accelerating effects of multiple technologies that accumulate into the meta-technology of civilization: improvements in transport technologies (domesticated animals, sledges, wheeled vehicles, better boats), growth/improvements in human "networks" (e.g. roads – such as the 85,000 km of sophisticated roads in ancient Rome; increased river/ocean routes) promote trade, (and the walls built to prevent trade and other interactions) unlocking improved productivity through comparative advantage, as well as fostering faster diffusion of ideas and techniques, which accelerate technology in numerous areas, which fosters more surplus, which is a pre-condition for investment, which increases resources, from which new technology can be created. With surplus, we see beginning of Mumford's "vexing problem of affluence". Role of culture, and "lock-in"; example - introduce Amanda Foreman's Çatalhöyük theory that modern's gender roles are shaped by cultural factors, as much biological (note, for example, the relatively low dimorphism in *Homo sapiens*); and her theory that the arc was changed as a result of Sargon's creation of the Akkadian empire, over 4 kya.

Describe how growing resources, specializations and other factors universally create a need for new concepts - monetary ideas such as taxation, advanced conceptual specializations such as math and other sciences, which then creates a need for more formal education. Each of these advances throws off additional productivity, and the overall system continues to accelerate. Segue to writing as a "special" technology, and with the rise of it, the growth of "extended" or "artificial" cognition.

Cognitive impacts of civilization, including comparison to cognitive traits that were required to survive/succeed in hunter/gatherer, and the cognitive consequences of techniques of civilization (such as the cognitive implications of reduced diversity of foods, increases in disease, changing navigation of increasing specialized social hierarchies).

- Sample chapter observation: discuss technologies of transportation, including the networks (growth of roads and ocean routes) and transportation technology (e.g. vehicles). Discuss how technology is not universally "forward" in terms of productivity, using the cultural lock-in and negative feedback cycle in the unique example of retrogression from wheeled vehicles back to domesticated animals, for long periods of time, and a significant portion of the world, including where the wheel was invented. (ie The Camel and the Wheel)
- Present relevance: Discuss how roads and aquatic trade routes are the world's first formal manifestations of the network effect known as Metcalfe's law. The same dynamic that accounts for Facebook's high valuation can be seen in the technology of transport routes of emerging civilizations. Unpack the diversity of "values" being sought in each technique, and teleology of how the unintended consequences of accumulating technology does not always equal "progress" when considered across the net gain of the impacted people.

Chapter 8: On Writing (and reading):

Mini-chapter, looking specifically at the unique technology of writing (and reading) (leverage Wolf). Note Socrates concerns that writing will ruin a person's memory. Examines roots of writing from systems of geometric symbols in cave art and pictograms on tablets and carvings, into formalized cuneiform, through to the modern systems of today. Examines how writing developed separately in at least 5 parts of the world. Role of trade and resource accumulation on writing. Refer back to role of women in early writing. Note prominent technological co-evolution of writing and civilization, and coincidence that nearly all civilizations had writing; sole exception being Incas, but they developed their Quipus. Brief discussion of cognitive differences in producing and consuming information visually (standard alphabets), versus tactile (quipus, braille).

Cognitive implications. Reading, like language, is not based on a biological change; as such it is "cultural" technology, and a "neuronal recycling" or, exaptive use of biological characteristics that evolved as adaptions to previous environmental fitness. In this case, the regions of the brain used for reading evolved originally in rapid visual processing (fast, unconscious pattern recognition circuits that connect concept processing to imagery; creating ability to determine at a glance if view contained predators or prey). These same regions of the brain are also involved in some linguistics, and even today are harnessed in some math processing.

Neuronal recycling or upcycling represents adaptive (not evolutionary) brain re-organization, and as such provides a good case study for understanding the way the brain reacts to adapt its biological tendencies to repeated stimuli in the course of a human's life. Can be characterized in 3 steps: the capacity to re-organize "older" circuits; the creation of extremely specialized functioning (e.g. the different circuits used for capital letters as opposed to those for lower case); and ability to learn to recruit these areas, automatically, and integrate them into the broader conscious and unconscious processes (Dehaene). How writing accelerates technology exponentially, by allowing complex techniques (tool, habit, social, abstract, etc) to be captured and stored, and then transmitted across time and geography. How writing is a system of metarepresentational concepts that bring those features of language into consciousness through communication (Olsen).

Discuss how evolution of angular gyrus, provides "association" cognitive ability better than earlier primate species, allowing the brain to better connect functioning across the whole organ. Enables better representational abilities - better ability to remember, recall and anticipate associations between visual images and meaning, quickly. More "meta-processing" or selfinforming. Isolate new circuitry in the back of the brain, between the angular gyrus and nearby visual processing that would have been recruited by early humans use of pictograms. With introduction of new techniques of logosyllabary such as cuneiform, there is a steep increase in use cognitive resources, both in the resources needed to store and recall the more complex visual images, and to process information between the visual processing at the back of the brain, the language processes in the temporal lobes, and the frontal lobes executive functions. The cognitive implications of introduction of alphabetically written languages, including the positive feedback loop that occurs between writing and spoken language (because alphabetical writing requires a conscious systemic study of vocal language).

Different written languages of the modern world occupy different parts of the brain. The cognitively generative and transitive nature of the neural resources needed to process unconscious feelings, form conscious thoughts, to transform conscious thoughts and unconscious emotions into to spoken words, and then to written thoughts (movements), and finally into visual images (i.e. reading your written thoughts) (leverage Vygotsky).

Address Socrates concerns: did writing ruin the famous Greek memory, and produce a false conceit of knowledge, and a reduction of critical thinking? Again – technology not positive or negative, but not neutral. "Net" gain, tradeoffs, and consideration of a range of values impacted by technology necessary to REALLY understand the impact of any given technology.

Summarize "technological" features and impacts, including diffusion impact with education, and segue to technology for the growth of sciences.

Chapter 9: Science

Mini-chapter on Science as a very recent phenomenon, in many ways, when you look at the vast scope of human history. Original discovery of the Neandertal, including methods and approaches, compared with recent progress on original site, 100 years later. Emerging role of science in warfare as recently as UK's WWII operations research efforts. Even the word "scientist" only goes back to 1834. Review "progressive" perception of science as steady accumulation of truth and facts, contrast with Kuhnian view that science is a dynamic of ideas competing within a broader intellectual, cultural, economic and political context.

Roots of scholarship go back as far as one dare, to the first time an animal studied a problem. Prehistorical evidence is slim; drawings and symbols as conceptual precursors; the indistinguishability between science, magic and myth. The transmission of increasingly systemized techniques like farming, through social practices and oral tradition. Earliest known written evidence of science shows continued blurring between science and magic, and indeed, Arthur C Clark says, "any sufficiently advanced technology is indistinguishable from magic". Geographic development - Mesopotamian evidence of studies of medicine, chemical properties, astronomy, and potential Pythagorean theory, 4 kya; advanced math of the Indus Valley, going back as far as 6 kya, followed by world's first astronomy, and studies off medicine, linguistics; China; and of course, Egypt and later Rome. Ties between science and education. Roots of formal education, spanning from Sumerian writing classes of 5kya, Egypt and China of 4kya, to Roman lyceums, and modern day.

Role of the Islamic Golden Age as a critical cultural bridge preserving and promoting classical science (Greek and Roman), and in advancing many scientific disciplines with innovations in astronomy, mathematics, medicine, chemistry, botany, agronomy, geography, cartography, ophthalmology, pharmacology, physics, and zoology. Algebra from "al-jabr", Algorhythms (which power much of the modern technological ecosystem) from 9th century Islamic scholar "al-Khwārizmī."

Harari's Scientific Revolution, and claim that the discovery of America fueled an age of European curiosity and exploration that typified the scientific revolution, and the cultural differences between the East and West. Key early building blocks of modern science: Boyle's seminal work in Chemistry in 1661, Hooke's geology concepts of 1681, Newton's 1687 The Mathematical Principles of Natural Philosophy, Smith's 1776 birth of economics. The role of glass in advancing astronomy and medicine (and other fields). The role of the printing press in advancing science as a whole, and "age of enlightenment", advancing philosophy, pioneering the fields of political science, scientific method. Pure glass innovations leading to spectacles, which can effectively double the useful mental life of a thinker/writer. Microscopes and telescopes, unlocking, literally, new worlds and understandings. Evolution of glass as a bootstrapping example. The pairing of military and science. The role of the amateur citizen "natural philosophers", like Darwin, Hutton, Boole, Humboldt, Babbage, Ramanujan and the technology vehicle of handwritten letters, and the technique of mail. Relatively recent origins of geology, psychology, sociology, anthropology, genetics, neuroscience, and the positive feedback loop between 19th century advances in the study of physics leading to engineering breakthroughs like widely accessible electricity, and these engineering breakthroughs as accelerants of more advanced science, through advanced inspection (x-rays), new forms of information storage (photography and records), transmission (telegraph, radio), and new forms of power/work (steam/electricity).

- Sample chapter observation: Note the pre-requisite techniques and the extended "weak" technology transfer before and after pioneering works of the computer age (Jacquard -> Babbage/Lovelace, with weak conceptual transfer to Aiken/Turing) and the information age (George Boole, via Shannon.)
- Present relevance: Compare/contrast "strong" digital modern technology transmission/accessibility over the analog book, letter, mail and in-person systems around for Babbage, Darwin, Boole, Humboldt, or even as recent as Ramanujan. The implications of unlocking a global exchange of ideas, and the ability to foster minds globally.

Chapter 10: Civilizations II

Uses the perspectives of:

- Society and culture V: Grid and groups and HEIF possibilities; the development of individuality as a value; Jaspers' axial age; the idea of (old) world government: Scythians, Chinese, Achaemenids; Mauryan Empire

- Technology V: engineering, alchemy, and the search for underlying concepts of 'reality'; conscious attempts to develop technological advantage by uncovering underlying fundamental principles as a guide.

- Biology, cognition, and intelligence V: the first professional intellectuals (Pythagoras, Confucius, Thales); the idea of aristocracy and the division of thinkers from owners, and freed from enslaved.

- Language V: the emergence of the concept translatability; algebra as a metaphor for word equivalence; Gellner: worlds and ways. The recognition of rival metaphysics and disparate ultimate goals.

Chapter 11: Globalization:

Uses the perspectives of:

- Society and culture VI: The longue duree and the 'Age of Discovery', the final age of empires.

- Technology VI: intercontinental transport and the mapping of the globe; the planet recognized as the totalizing resource base. De-ritualized science replacing guild tradition and 'mixed' concepts regarding the nature of material reality.

- Biology, cognition, and intelligence VI: Philosophical discussion on the nature of the species and its equality/inequality in intellectual and cognitive terms; recognition of the power of habitus; recognition.

- Language VI: the collation of libraries and comparative linguistic archives; the emergence of new recording technologies – perspective, cameras; musical notations.

Mumford's "invention of invention". Examines technology development and diffusion from the Middles Ages up the Industrial Age, (i.e. covering Middle Ages, Renaissance) including the enabling factors, key techniques and technologies, rates and vectors of technology. Unweaves the meta system of the modern-day "Technology" ('the overall system of interaction between people and technologies, including the emergent effects of all of the returns from underlying technology creating positive feedback loops; as distinguished from "technology", which is itself the diffusion of techniques) into the earlier pre-cursor technology domains, to establish various baseline. Evolution of human labor, including factors such as specialization, slavery, key industries. While writing, the printing press and industrialization are, appropriately, models for technological innovation, a number of underlying technologies are, in their own way, critical pre-cursors, or lesser heralded techniques with broad technology implications. Chief among these might be both the transition from human power to a basket of techniques of non-human labor, and the 'reinvention' of freedom in the form of new labor saving devices (freeing up time), emerging concepts of religious freedoms, and emerging human rights, as well as the social experiment that is America. All of these have had long lasting global impacts, and unforeseen consequences. And sometimes missing from the idea of a technique and technology development is the interplay and interdependencies between other fields, which is often the most important proximate factor in the innovation.

Of course, the printing press did have enormous effects, and is itself an iconic case study in technology diffusion from adjacent industries (such as agriculture, textiles and metalworking), detailed here. And the effects were obvious: 3 million manuscripts were produced in the 14th century, before the printing press; and information diffusion grew to over 1 billion per century by the 19th century, due largely to printing press technologies.

Changes roles of energy productions, and resource extraction/production and consequences (e.g. adoption of coke instead of coal as a key factor in making less expensive iron as a pre-condition to the Industrial Revolution.) Detailed review of innovations within agricultural techniques, and the factors affecting diffusion adoption. (E.g. crop rotation as being as important as the steam engine; diffusion of crop rotation reviewed). Introduce the concept of open versus closed networks. Discussion of Benedictine monasteries as laboratories of applied innovation. Changing modes of transportation, and globalization effects on cultures, with references back to "cultural intelligence" (though, the time it takes to cross long distances on land, via horse messenger, remains virtually unchanged from ~500 BCE to the development of rail, after the Industrial Revolution, a period of almost 2,400 years). Role of new abstractions, like time, and the factors that created a demand for it, and consequences. Review evolution of technologies of medicines, warfare, construction, infrastructure, and the factors affecting the trend towards urbanization, as well as changes in political/social governance technology. Chart the arc of mechanization from complex tools of the past to increasingly sophisticated machines like the Jacquard loom, and increasingly complex chronometers.

Document key aspects of humans, as a species: changing life histories, diet, morphology, social structure (family and other), environments, activity budget, causes of death. Social characteristics such as patrilocal tendencies, compare/contrast with primates and earlier humans. Note climate changes, and impacts.

Summarize the complex interdependencies of the past, as a simplified case study; foreshadow to compare and contrast to the modern era - when we are fundamentally altering every technological domain at once. Note that while it is hard to understand the simple and relatively loosely linked technologies of the past, it is nearly impossible to perceive today's interdependencies. Introduce Club of Rome's definition of "problematique" – the modern era as a meta-system of inter-twined dynamics and problems (aka "Technology", as opposed to "technology"), and Rittel's concept of "Wicked Problems".

Summarize cognitive implications as a result of the technical and technological evolutions above.

- Sample chapter observation: Use case study of Cortez, 500 men, captures a culture of millions, using the accumulated benefits of all of the above, forever altering to Cortez, Mayans, and the people back home
- Present relevance: Impacts of punctuated equilibrium currently underway on cognition; not from some external forces, but from the consequences of our own activities

Chapter 12: Industrial Revolution

Review focused on causes, effects of Industrial Revolution (aka First Industrial Revolution of ~1760 - ~1840), as well as detailing the vectors, pacing, interactions, impediments for technology diffusion between key technical innovations. Examine (briefly) key technical innovations that typify this period, but note how and why they arose among complex pre-industrial energy economics that set the stage for key innovations by creating markets of demands, via changing economics of wind, water, coal and labor, among others. Changing social factors of population growth and further urbanization. Vectors of changes in transportation, and pre-adaptations to subsequent transportation revolutions (e.g. steam engines as pre-adaptation for rail and shipping transport disruptions).

Brief discussion on the surprisingly increased amount of labor in hours per week from medieval peasants (with scores of holidays) to the industrial worker. Example how 'technological progress' is not always forward across all value categories.

Rise of capital as technology. Distribution of capital accumulation within a population, emergence of the middle class (a term first coined in 1745), and literal and figurative appearance of the bourgeoisie (translation: "town-dweller"). Note the logical constraints on limits of consumption of natural goods, and the lack of constraints on consumption of capital. Break down the range of human "values" being pursued by technical innovators (including improved economic power, individual wealth, moral/religious). The substitution of economic output for progress. The "weaponization" of economic efficiency, as a source of imperialism, and the international and intra-national market forces that are created and locked-in via that mechanism. Note the delay often associated with new innovations, and the accrual effect over time on their subsequent productivity benefits; deeper dive on sigmoidal growth's iconic S curve that arises as a function first of positive feedback loops (acceleration), and at maturation, of negative feedback loops as resources become constrained as a system approaches a carrying capacity (deceleration).

Case study examining the interplay between the Agricultural Revolution and the Industrial Revolution. E.g. the unintended consequences of increased tin output (as function of steam engine water pumps), and innovation of new methods of preservation (tinned foods), and the positive feedback between mining and agriculture, represented by the emergence of the science of geology. As much a spontaneous "random walk" as a steady rational planned "progress". Document the early/extended history of steam engines development, and protracted role on future science (Carnot to Kelvin to Hubble). Compare/contrast the *technical* innovations between steam engines and the cotton gin, versus their respective *technological* innovations, including subsequent diffusion/adoption, and the role of intellectual property rights and other market forces.

Summarize cognitive effects of this short 80-year period of human history.

- <u>Sample chapter observation</u> Note that UK GDP per capita stayed flat through Industrial Revolution, and didn't see massive spike (10-15x) until last 150 years. Why not? First, delayed benefits (sigmodial curve). Second, against the backdrop of human history, other innovations (e.g. major revolutions such as the printing press) similarly don't have visible impact, in part because the mechanisms for diffusion and accumulation aren't as robust in the past, when compared to the steady drumbeat of Technology innovations since IR. Lastly, economic benefits of the IR to England was that it allowed the empire to expand GDP by expanding the number of people it could support.
- <u>Present relevance</u>: Note the economic consequences of expanding GDP by increased productivity per capita, versus by expanding population, and ability or limitation to understand technological innovation on future GDP growth (as a prime "value")

<u>Chapter 13: Age of Change:</u>

Document the massive changes to humans since the First Industrial Revolution (~1840):

> *To observe the scope and rapid pace of change of the last 150 years, go to Oregon, in the western United States, and take Route 242 to the summit of McKenzie pass. This route was a native American trail for millennia, up until as recently as the 1860s, when it saw its' first white man come through the pass on horseback. 10 years later, the pass saw its' first wheel, when the first covered wagon came, and by 1910, the first automobile struggled over. And just 50 years later, Walter Cunningham tripped on the rough lava that makes up the ground of the pass, ripping his prototype spacesuit, while training for his Apollo moon mission. Today, if you look west down the pass, you can see the 100-foot microwave tower that Qwest Communications uses to transport high speed wireless data over the mountain range. In last century and a half, the hardy windswept hemlock trees growing on the pass witnessed a human culture that was relatively stable for millennia be disrupted in rapid succession first by technology-driven human migration, then by the industrial age, the space age, and now the information age. We entered the period with, as Mumford says, "this smug Victorian belief in the inevitable improvement of all other institutions through command of the machine" and we fast forward to now, when the messages going over Qwest's microwave tower increasingly signal the world's*

bewildering complexity, and our perception of numerous existential threats to us, as a species. All in the evolutionary nanosecond. How to navigate?

Highlight that much of the gains of last150 years can be characterized by massive spike in productivity per capita. Inflation adjusted, has been stable throughout human history (despite technical and technology innovations such as civilization, the printing press, glass, science, etc.) at or below ~$3,000 per year, but has seen 10-15x increase, globally, in industrialized countries, since mid-19th century.

Document change in adoption speed of new technology, from ~60 years with telegraph, to ~10 years with Internet, and to even faster cycles with mobile phone apps and 'cultural memes'. Individual and societal effects of rising wealth. Refer back to Mumford's "vexing problem of affluence", in which Egyptian and Mesopotamian rulers' boredom/depression from living lives "in which every desire is too easily satisfied". Now problem/opportunity space scales to a growing number of billions of people across the world. Economic concepts of growth, and lockin effects implied within the model.

Chart network effects: speed of networks (e.g. communications between London and New York went from weeks to milliseconds, while the time it took to move passengers and urgent freight went from weeks to hours), nodes of networks (e.g. from letter writing to smartphones/Internet of Things); purpose (e.g. telegraph was 80% commercial messages; modern networks are predominantly entertainment). Exponential growth of physical networks (e.g. UK rail miles went from a few dozen km to over 30,000 by WWI), and exponential growth in marine freight tonnage. Massive increase in amount and rate of recorded data. Use Krakatoa's 1889 eruption as the first "global" event in human history, and an example of a network evolutions, and 'shrinking global' are the result of a number of technological changes. Compare contrast with Tamboro (1815), and network effects of Anak Krakatoa (2018). Lower/disrupted network economics; morphing from physical to electronic and then to digital, and new domains of space and virtual worlds. How, during this period, innovation in one domain of change after another allowed those domains to be effectively rewritten (e.g. germ theory of medicine transforms human mortality/morbidity), and then those changes cascade into other domains with specific gains further accelerate other areas, creating a positive feedback loop of change. (e.g. better health care extended the useful/inventive lives of Babbage, Edison, Tesla). The increasingly rare myth of the "solo inventor", in today's age, with examples.

The case for a pending punctuated equilibrium: reviews how the last 150 years have changed all of the key forced that lead us to our current biological and cultural intelligence: e.g. – dramatic changes in life span, life history, locomotion, diet, education/parental investment (including the 'invention' of mandatory public education at scale), social structure, social behaviors, range, communications, ecological niche. Refer back to primate evolution and how cognition would evolve in response to any ONE of these major changes, and now we are changing ALL of them, dramatically, at once.

Outline "the Great Divergence", between the Industrial Revolution's effects on western vs eastern cultures, and the theories behind why innovation such as the Industrial Revolution had such different effects on the east versus the west (including Harari's argument that western society was pre-positioned for success with infrastructure of transportation and laws/policies).

Document changes in daily human activity budget, including large decline in hours worked, and increase in leisure. Changes in causes of death. Case study in changing modes of industry and labor: in US, agriculture accounted for >60% of employment 150 years ago, and today accounts for less than 2%. Yet our total production and yield (per acre) have gone up 4-10 fold. Case study on the innovation of one technology –refrigeration, and its' expanding impacts on other areas of technology (s curve playing out). Diet changes as a result of evolving technologies: e.g. agriculture, transport, refrigeration, political.

Highlight how technical invention is a 'use of resources to pursue a valued ends', but the nature of invention is one highly characterized by struggle, failure and loss: historical fate of many inventors (e.g. John Gorrie's technical innovation of refrigeration; Watt, Tesla, Sutter, Whitney, Armstrong, and Goodyear – who wrote in 1950 "The history of invention proves that whoever attempts by inventions to improve the conditions of others, usually impairs his own, except so far as he may add to his happiness from the satisfaction of having done good to others.") Compare back to negative feedback pressure against innovation among earlier primates. Chart technology of failure from Babbage to Edison to 3M.

Case study in culture and luck – The "luck" of Gold Rush/Silicon Valley and how this influenced the role of US on the world stage: likely enculturation for a tolerance for risk/failure; a catalyzing US infrastructure investment in rail, communications and other enabling technologies, setting the stage for uplift of entire US economy. Link Gold Rush (and associated culture/population shifts) with rapid California economic expansion in agriculture, followed by the founding of entertainment, defense/aerospace, transistors, computers, venture capital and modern Silicon Valley "technology industry". Document early organizing forces, including Edison's tight control on east coast movie industry practices pushing emerging movie makers to the west, and the importance of Stanford University to subsequent growth, timing and impact of 20^{th} century wars. Direct link from world's first wireless communications in San Francisco, to HAM radio, to founding of Apple computer. Resulting economic success of this chain of events (together with other US industrial and technological innovation), culturally exported throughout the world, in part because of Hollywood. But US is unique in its GDP productivity, extraordinarily low pop density (per square mile), outsized natural resource and energy consumption. Given existing technologies, not a sustainable niche, if rest of world follows, even before consideration of climate change. (i.e note the high K (carrying capacity) of the US, and the variation of carrying capacities across the world; also, negative feedback factors of economic growth, and their geographic variation.)

Review of the current literature on technology development and diffusion, and central themes and insights from this period. Note that terms that refer to exponential growth as explosive are actually backward: explosions start fast and slow down. The Age of Change is a snowball: it starts fast and speeds up.

Cognitive effects: Flynn effect (substantial long term increases in fluid and crystalized intelligence, as measured by IQ, over the last 100 years in developed countries). Limitations of IQ as a measure. Causes of the rise may include technology of improved health, nutrition, education, standards of living, and overall changes to life history. Also, perhaps increased complexity of modern life/media. Discuss how and why decline may or may not be occurring in recent years. Note the lag effect traditionally observed in technology (s curve), and how much has changed recently (multiple s curves). Note the psychology of "Revolution of Rising Expectations" hypothesis, and alternate explanations.

Globally - Extreme urbanization, and emergence of the mega-city. Rise of political technology in the form of supra-regional, multi-cultural global social structures: Olympics, UN, NATO, international standards setting organizations (e.g. IEEE), international NGOs (e.g. Doctors without Borders), new social movements. A shift towards a democratization of power, changes both in form of governance and social participation, much of it powered by new technologies that "open" traditionally "closed" cultures. Both a form of egalitarianism and technological imperialism. Document the rise of the counter-technologists from luddites to Amish to Digital Minimalism (e.g. Discuss the concept of a moral panic, from Socrates concerns about writing, through numerous concerns about bound books, from the time of first printing press and Martin Luther, through the 18th century Novel Reading moral panic; the NY Times 1877 attack on the telephone, critiques against the telegraph, Marconi's own doubts on radio, Charlie Chaplans' view of cinema as fad, Zanucke's view of TV as a fad, and IBM's Watson quote "world market of 5 computers". The distinction between understanding a period of rapid change, and hyperbolically hectoring against it. The unique case of Stewart Brand. Social efforts of Vint Cerf and Bill Gates). Segue to one domain that neatly characterizes the changing era: energy.

- Sample chapter observation: Compare/contrast affluence and abundance of people in the industrial revolution era, with those of the modern developed societies. E.g. rising affluence, and effects on consumption, diet, health, discretionary time/decisions: review of technological innovations on chores, housework (Compare Vanek's influential 1974 paper with more recent Gershuny et al).

- Present relevance: In short, in the time since the Industrial Revolution, humans are experiencing an accelerating extreme environmental shift from a niche of resource scarcity to a one of resource abundance, and we are still struggling with how to adapt to this niche.

Chapter 14: Energy, as technology (mini-chapter)

Conceive of energy as the one universal variable which can describe humans' innovations over time. The etymology of "energy" is from ~500 BCE, "en-ergon" used to describe "the father of everything . . . and the source of all activity". Chart improved human energy use through mechanics (tools), fuel (improved hunting), domestication of animals, new fuels (coke, fossil fuels), prime movers (e.g. steam turbines), and new ways to transmit and store energy (e.g. electricity). Introduce key concepts and terms, such as energy rate density. The idea that culture itself has been defined as a quest to control greater energy stores.

Demonstrate a three-fold increase in energy consumption per person in the 1,500 years between ancient Rome and the Industrial Revolution, and the five-fold increase in energy in the United States since the Industrial Revolution.

Chart how Age of Change can be illustrated with energy variables: a farmer in 1850 using two oxen to plow his stony field controlled about 500 W of energy, and he used about 2.5 kW to have a team of horses to drive his goods to the city. In 2000, the farmer drives a tractor which harnesses up to 300 kW (600x increase; not 600%, but rather 600000%), and the 737 pilot has about 10MW at her fingertips to transport the farmer's goods across the world (4,000x increase).

We begin the Age of Change with a "cowboy economy" view of wide-open frontiers and unlimited resources, but we arrive, now at "spaceman economy" perspective of a closed system, with limited resources. Of course, this is not a completely closed system, from a physics perspective: it has elements of an open system as human societies follow thermodynamic principles to harness energy centrally to exist in a high state of non-equilibrium, in an environment of constant change. And there is massive geographic (and cultural) disparity in energy consumption: US uses 300 gigajoules of energy per person per year. Japan about 170, EU about 150, China is close to 100, but India is 20. Nigeria is 5, and Ethiopia only 2.

Changes in sources, transitions (wood to coal, coal to oil, and coal/oil to natural gas, and now a fourth transition to renewables) and economics. Surprisingly weak connection between energy access and human development, in the modern world (due to lack of other critical technologies, such as appropriate governance structures).

Connection between cognition and energy; thinking, in any form as an energy-intensive affair: for an individual (the adult brain, which is only about ~2% of our body, requiring ~20-25% of our daily calories; newborn brains consume up to 60% of their calories), or a society (data centers consume 3% of world's daily electricity; a global total that is equivalent to 40% of an industrialized country like the UK).

The idea that, even among developed societies, technologists are by far the most energy intensive individuals.

Chapter 15: On Capital, as technology (mini-chapter)

The shared myth of money as an enabling technology commodity providing for efficiencies in exchange. GDP as a measure of economic productivity, including its pros and cons (e.g. compare and contrast with UN's HDI, or Word Economic Forum's IDI). Growth as central assumption in economics. The importance of credit to a capital system, and the huge disparity between physical money and "imaginary" money. Note the contrast, during a huge period of economic expansion of the western world, with rising debts, individually and societally. Affluence shifts – as the markets in developed countries goes from meeting basic demands to the creation of markets of wants. (Galbraith – "Few people at the beginning of the nineteenth century needed an adman to tell them what they wanted.") The dependence of modern growth on these continued needs (via growth). The continued virtualization of capital through credit cards, as an increased efficiency in consumption. The virtualization of product and consumer goods, through rise of digital goods. Emergence and significance of venture capital industry. The development of mobile wallets, and changing ways we pay for things.

Cognitive impacts:
Self-fulfilling prophecies of psychological outlooks. The psychology of trust in a currency, and role that shifting trust in government systems as a conditioning factor in the emergence of new techniques and technologies such as crypto currencies. The psychological divisiveness of manufactured wants.

Chapter 16: On Governance, as technology (mini-chapter)

Discuss the role of social governance, as a technology, from small groups of similar people with tight direct social bonds, to very large groups of different people, loosely connected over great distances. Historical tendencies for power consolidation and inequities. The primacy of the feudal model, and alternatives. Harari's point that the shared values, myths, judicial apparatus and sociopolitical structures of the West allowed them to see outsized gains after the Industrial Revolution (the Great Divergence). But also Galbraith's claim that the "central tradition" of the millennia of western society was one of ubiquitous poverty, and that the widespread affluence of the 20th century would require new forms of government, and that the future problems of the society will rely on "resources of intelligence and education".

The rise of technocracies, in both government and large corporations, to manage increased complexities. The role of digital communication and rising expectations converge to create unprecedented issue spaces for government. Governments around the world wrestling to move beyond security, jobs and justices to more sophisticated reforms. Growing ability of technology to fuel social movements (e.g. holacracies; "grass-roots" or "leaderless" initiatives) to move faster than government (e.g. Facebook & Twitter in Egypt; HKMap and Telegram in Hong Kong). The rise of civic-society and public/private partnerships (e.g. transition from guilds of old to new: E.g. efficient skills-training and apprenticeship programs, that involve municipal officials, schools, unions and employers.) The role of digital technologies like smartphone apps to empower political reform such as microfinance, fishermen's "shared economy" ventures, diverse initiatives in green and alternative energy, microfinance, and massive open online educational courses.

In short, a massive uplift of the average person out of grinding poverty, into a world of growing human rights pre-conditioning changes in social structure and governance. But also, ironically, dramatic increases in wealth from the top, who are uplifted even more, and the middle classes. All occurring at a time of increasing openness, increased information, and increased diffusion potential. Unlike in the past, where technologies were developed and then lost to the world for millennia (e.g. clear glass lenses and obstetric forceps), new ideas are harnessed and engaged quickly. Governing in an era when it is by far the best time ever to be a human, and yet ironically, people are increasingly dissatisfied with their lot in life and with their government, largely because of technological media diets they attend to and psychology of rising expectations.

The cognitive impacts of the fractioning of shared myths, and eroding moral authority. A rise in "moral injury" at government (e.g. Greta Thunberg, at the UN). The need to rebuild trusted leadership in national, international, and civic entities, and the role of greater equality as a key building block in that process. Managing through a period of change, as both present day job losses to technology (e.g. loss of manufacturing jobs to automation), and prospects of major future job losses to numerous technologies (e.g. self-driving trucks disrupting the millions of people who do that for a living).

Chapter 17: Cities as a technology

Brief discussion of the "city" as a technology. Smil: "*cities were the first complex anthropogenic creations*." How/why cities are the place where many of the world's most seminal technology breakthroughs, from Uruk, to Rome and London. How concentrations at scale allow more and broader connections (Metcalfe's Law), and concentrations improve infrastructure investments, which foster greater innovation.(e.g. compare/contrast economies of scale of rolling out 5G wireless networks in a dense urban area, versus rural one) and enhanced employment opportunities, but also downsides such as the lack of economies of scale in urban energy use, and increases in crime, traffic, pollution and disease. Like any technology, there is a mix in results, across a range of valued outcomes.

City as cultural constructions, but having biological patterns subject to physical laws (e.g. metabolism of the city as viewed through its' energy budget as similar to caloric budget of living being). The pace of changes to the culture itself is itself increased, as social engagements and innovations develop and diffuse faster.

Discuss the relative newness of cities of >50,000 population, from an evolutionary sense, and the subsequent rise of cities, and now mega-cities, in overall populations as well as percentage of the world's people is driven by the effectiveness of the "technique" of the city. (e.g. how Tokyo has more residents than Canada and an annual economy the size of Australia; and US urban population went from 28% a century ago to 84% today). Note that the "progress" of a city is not ever forward. Citing historical cases of Babylon, Troy, Angkor, and Teotihuacan, and modern cases of Detroit and potentially New Orleans. Note rising complexity of the city itself. Chart the "values" that rise within urban settings, and which "values" fall (e.g. Discuss how migration from rural/natural environments to urban/built have geophysiological effects, particularly on activation/mediation of autonomic nervous system.)

Chapter 18: Present day

How humans perceive their environment has radically changed in just the last generation: Americans now consume >11 hours of digital content every day, including > 5 hours of TV, and 2 hours of social media. They look at their mobile phone over 200 times a day. As these now "traditional" media account for much of the average person's day, new technologies are rapidly emerging and gaining traction, such as VR/AR, IOT/IOE, 5G and much more.

Why do humans engage in these technologies the way they do? Chart with reasons why, noting prominence of unconscious needs, driven by early human traits as drivers. Compare and contrast with the "conscious" goals expressed for these behaviors. Note that each of us is a "congress of selves", (aka- 'society of the mind'), with multiple competing needs being pursued simultaneously within our own heads at any time. Note how modern media appears to affect us, with respect to the various conscious and unconscious, often competing values. (IE view modern media diet through the lens of techniques as 'the ensemble of practices by which one uses available resources in order to achieve certain valued ends'). Compare this change with the transitions of tool use between early *Homo* to amHs, and then again with bmHs.

How do these media behaviors, in turn, change us, and affect the way we think? Document, anthropologically, the changing morphology, senses, communications of modern humans. Use listening to music as case study, align with reading, for re-organization of the brain, with fMRI, PET and other evidence. Use the well-established London cabbies' brain (hippocampal) changes. Cover existing research of brain re-organization as a result of TV, video games, internet. Examine neural consequences of transition back from writing-centered learning back to image-centered learning, but a visual environment that is highly edited and mediated multi-screen, multi-stream, linear and non-linear imagery. Deep dive on the brain's Default Mode Network, and its relevance to modern 'screen' tech. Discuss how the diffusion of new digital techniques and technologies changes our social structures – in the way we coordinate (e.g. global real-time collaboration of the Boeing 737 design), planning (e.g. cell phones used to plan, pitch and fund new business plans in Africa). The way we work, and relearn how to earn money, as technological automation changes the demand for human workers. Development of new techniques (e.g. digital twinning in manufacturing), to diffusion (e.g. distribution of 3d-printed gun plans over the Internet), value (e.g. changing valuations of Facebook, as a company, or one's social status, based on Facebook likes) or to disruption in products we produced (e.g. AirBnB, or World of Warcraft, and the fact that data is now more valuable than oil). Also, the increased complexity. (e.g. Boeing 737Max so sophisticated that the safety engineers couldn't understand what they were certifying). Review of modern lifestyles and interactions with technologies and media, and how the market demand for media in turn shapes the supply of it. Attention as a driver of production. Changes in humans as a result of technology, from increasing lifespans, to introduction of lifestyle diseases, and changes even to menarche and other reproductive parameters. Notes that the role of new technologies in just the last 10 years which allowed large number of new insights in the book: from DNA and brain imaging methodology of the underlying research, to process of authors researching and collaborating on this book series.

This deep review finds not that technology is not uniformly good (e.g. Kurzweil et al), or bad (e.g. Carr, Greenfield, Postman); it dynamically effects *within each individual* multiple consciously and unconsciously held values, improving some, eroding others, and the effects change over time (i.e. not static determination) – so technology is definitely not neutral.

Make the case that human thought in the present day is undergoing "disruption" in the Clayton Christenson sense. Develop the argument, with detailed examples of the past techniques associated with changes in cognition (across primate and human evolution) and note how they are all being changed simultaneously in the present, which may have serious effects.

Present a model of the human mind that is consistent with the past, and usable in the near future: a marble layer cake of a) massively modular and layered human brain that largely operates unconsciously due to inherited traits, and shaped further by b) cultural habits, values, and learnings that have been ingrained into our thinking, largely processed unconsciously, that is manifested in our own brain, but also in the shared mythologies of other people, and cultural artifacts as well as c) a growing "extended cognition" of largely digital platforms that act as an "exocortex" of memories and processes (e.g. our computers, smartphones, smart speakers, cloud computing and other computing devices as extensions of our own minds).

Note that technology is now evolving algorithmically, as constant change in various valued human domains has positive feedback effects on the other domains (multiple s curves interacting, while new ones enter into the mix as well, with generally positive feedback loops between them creating complex emergent growth). Discusses impact on social 'equilibrium', and
considers technology impact not just to GDP, but across a broad range of values, such as in human rights frameworks that consider safety, health, education, justice, living standards, economic opportunity. (e.g. rights laid out in Universal Declaration of Human Rights ("UDHR"), ICCPR, and "CESCR.) Mix of positive and negative effects, with a need to drive towards more equal distributions of opportunities and benefits.

<u>Chapter 19: Ultrabiological technology</u>

Discusses how Humanity has consistently used various technologies to harness energy and engage with our environmental niche far beyond the limits of our biological resources. We've evolved through survival of the fittest ("nature") and developed and adapted to various physical and civilizational tools ("culture") to get us to here. *But something different is going on now.* We're now developing a new ability to dramatically *escape* the limits of our biological condition. It's a technology stream that was hard to perceive in the past but is clearly emerging in the present. We call this "ultrabiological" - defined as technologies that are *of and beyond* the biological conditions of the human species, but also offer a unique ability to *shape* the human condition, going forward.

Review of past ultrabiological examples, start with glass (which artificially extend our useful vision to see both microscopically as well at great distances, leading to untold advances in many fields from biology to astrophysics), and up through to increasingly sophisticated prosthetics, and human machine teaming technologies (thanks largely to various military conflicts, interestingly). Looks forward, slightly, to imagine the near future, and then asks the question So – what?, unpacking three key insights that we face today: the realization that something different is going on now than ever before (an emergent property), realization of the startling speed at which technology is accelerating, when viewed through the long lens of human history, and third 0 the importance of the networks of interdependencies and feedback loops between the domains of technology.

This is about understanding that with the numerous changes to the human species and environmental niche, not the least being the introduction of ultrabiological technologies that begin to eliminate the constraints on our biology, we can expect massive change ahead, some of which is predictable. It won't be evolution, though, in the traditional sense: the timeframes are too short, there is a lack of selection criteria and changes to reproductive techniques, and instead of geographical isolation, we see greater than ever geographic mobility and genetic mixing. But, by looking deeply at the past, we can see that something is coming in the future. The causes of that change are rooted in our humanity, and what comes next will be human, because it will happen too fast for it to be anything else. But we can work towards making those humans healthier, more effective at achieving their goals, and more equal in opportunity.

Chapter 20: Technology of Want

Historian Yuval Harari concludes Sapiens, his acclaimed deep survey of the *Homo sapiens* species, with a worry: "*In the past 1000 years, humans have evolved to take over the world and are on the verge of overcoming natural selection and becoming gods. Yet, we still seem unhappy in many ways and we are unsure of what we want. Is there anything more dangerous that dissatisfied and irresponsible gods who don't know what they want?"*

This chapter explores the concept of wants as a technology, and the unique role of advertising as a technology, and the interconnections between this triumvurate

Chapter 21: So What?

Personal observation on this unique time we are living in, and the lessons learned from working on the book. Material reviewed so far leads the authors to believe that the issues being addressed by this book are among the most pressing of our time, and not well understood, in part because of how complex they are. This book arrives at the conclusion that dozens of the factors that were critical to evolution of how we think have changed in the last generation, and that any one of these changes would have been dramatic when viewed across a long span of human and primate evolution. But changing all of them, at once, is even more noteworthy. We are on the cusp of something new and different.

Concludes that thinking is now maladaptive, and give us an inaccurate view of the modern world, we've created for ourselves, but presents this as an opportunity to leap frog past archaic cognitive platforms of the past, and to design new and more effective modalities and outcomes.

End with final messages and calls to action for the various readers: individuals, researchers, corporations, legislators, teachers, others.