Chapter 15 – Societal Systems

Abstract

This chapter will provide a glance at the application of systems theory (chapters 2 and 3) to the analysis (chapters 5 and 7) of the most complex adaptive and evolvable system of greatest import to humanity, the human social system (HSS). In previous chapters we analyzed bits and pieces of the HSS, especially chapters 6 (as a part of the Ecos) and 8 (the biophysical economy) as it exists. We found that the HSS of the modern world is highly dysfunctional in numerous ways. Then in Part 3 we examined three four archetype models of real-world systems, the CAES as a whole and the agent, governance, and economy models that combine to make up a functional CAES. These are the models that are to provide guidance in the analysis and design of an 'ideal' HSS that can operate within the context of the Ecos. We start by considering the deviations in the implementation of the current global HSS from the archetype models in Part 3. Then we turn attention to what a design for a functional, that is sustainable, persistent, and stable HSS would look like if we follow the pattern/model-based design approach given in the last chapter.

Purpose of this Chapter

Arguably, a modern, technologically-enabled, culturally diverse society is the most complex artifact that humans have created. It is made more so given that humans are not only the constructors but are components of that artifact. The global HSS is a complex adaptive and evolvable system to be sure, but is it a good one? The word 'good' has a specific interpretation based on systems principles. The HSS is now understood as a subsystem of the Ecos. A 'good' subsystem is one that provides benefits to the supra-system in which it is embedded. A subsystem that fulfills its purpose, relative to the supra-system's needs is a good one.

What purpose does the HSS have? More importantly, what about the HSS is good for the planet as things stand today. Many people both lay people and specialists from multiple disciplines are rapidly coming to the conclusion that mankind is in the process of harming the Ecos.

In Chapter 8 we examined some subsystems in such a society, largely focused on the neoliberal capitalist-based economy as it is found today. That chapter revealed some significant deviations of the modern society's economic subsystem from the archetype model presented in Chapter 12, most particularly the reliance on finite stocks of hydrocarbon fuels for the majority of high-power inputs as opposed to the real-time flows of solar energy.

The current HSS is unsustainable.

Its form, a set of nation-states along with a few peripheral units such as aboriginal tribes, each pursuing its own agenda and most based on the pursuit of a growing economy even as the availability of natural resources is declining (and pollutants are accumulating) is the result of a mix between auto- and intentional-organization. The latter aspect, an example being the development and adoption of constitutions, is also a mix of short-term and long-term thinking. But the latter is too often trumped by the need, seemingly, to solve short time-frame problems.

The disparate forms of current governance and economics of the HSS are the result of the same kinds of evolutionary dead ends that mark the extinctions of species in the tree of life. Evolutionary adaptations that seemed appropriate in one environment turned out to be non-adaptive as the environment changed more rapidly than the species could evolve. Similarly, the various societal systems that co-exist today have evolved to fit one set of circumstances, say the availability of "cheap" fossil fuels and through unintentional niche-creation (depleting resources and polluting the atmosphere) have sown the seeds of their own maladaptation.

The irony of the human condition is that after evolving a kind of intelligence and creativity that could learn virtually any concepts and solve many problems, and applying that cleverness to finding new ways to make a living, we humans rushed to choices, in terms of ways of governing our social systems and conducting economic activities, that, in retrospect, seem incredibly foolish. As revealed in Chapter 8, for instance, adopting the assumption that markets could solve all economic "problems", and as shown in Chapter 12 not to be the case. Or, in a similar vein, adopting the notion that a capitalist, growth-oriented economy (with accompanying growing population) was the best way to provide for the common good has turned out to be at the base of the causes of our current predicaments (Kline, 2015; Kolbert, 2015).

There are a number of explanations for the reason that human societies have become maladapted to the modern world that they, themselves, created. One proposal by this author posits that human evolution that had produced an incredibly clever primate at the end of the Pleistocene era got sidetracked, so to speak, when that clever species invented agriculture (Mobus, 2012, 2019). The theory, in brief, was that human beings were the first species to evolve a brain significantly able to provide strategic thinking capabilities. Evolution had selected for beings able to think about alternate futures and to enter into the intentional-organization ontological cycle (Chapter 9).

However, we also recognize that human beings started with no concept of how complexifying culture would eventually affect their successors. The knowledgebase of humanity was limited to natural ecosystems and how to construct primitive tools at the end of the Paleolithic age. It would take many thousands of years to accumulate more knowledge of the physical and biological worlds, let alone the psychological world. Fundamentally, the search for a workable form of society has been an evolutionary process with auto-organization replaced with intentional-organization, but intentions based on best guesses and not any definitive knowledge of humans as individuals (e.g. psychology) or in social organizations (social psychology.) We were ignorant of what the effects of scale or complexity might be. It has taken thousands of years of experience to begin to accumulate an understanding sufficient to consider a systems engineering project to realize a new social contract and social structure that could achieve a sustainable society.

But, the discovery of agriculture provided another effect with respect to the evolution of the average human psyche. A careful examination of the management needs and practices of early agriculture indicate that the greater emphasis was on logistical and tactical thinking with a greatly reduced need for strategic thinking (partly a result of living in fixed settlements). Thus, selection for greater capacity for strategic thinking was diminished and for the last 10,000 years or so the vast majority of the gene pool of humanity has been subject to selection for logistical and tactical thinking, both as individuals and as groups.

Logistical thinking (making sure the crops were irrigated) is very short-term in scope. Tactical thinking (protecting the crops from marauders) is not much longer-term. In the short-run, the application of cleverness to immediate problems took precedence over thinking about the consequences of over-extraction of resources (like forests, ground water, and soils) in the future. Humans were ignorant of deep scientific knowledge. They were motivated to acquire all the “wealth” they could in as short a period of time as possible. They invented artifacts that allowed them to literally rape the earth. Historical baggage in the form of cultural practices (“we’ve always done it that way”), lack of systems knowledge, expansionism, acquisition-ism, all of these factors have carried into the present (Crist, 2016). The consequences of these practices look dire at present. They will need to be abandoned in favor of more sustainable ways.

The question we address in this chapter is: If we were to tackle the design and engineering of an HSS based on systems principles and especially the CAES archetype, what would that system look like? How would it work? In this chapter we will tackle the systems design and engineering of the human social system (HSS) based on the CAES archetype (including the three sub-model archetypes). The reader should recall Figure 6.2 in which the HSS is shown embedded in the whole Earth ecosystem.

This may not be a useless exercise. As noted, the current forms of civilization are not sustainable. This means, quite simply, that the global civilization could very well collapse. Given the recent revelations regarding the rate of climate change and the severity of climate chaos the risk of collapse seems not at all untoward. We could lose everything that constitutes what we have come to accept as normal society. In that event, wouldn’t it be good to have a design for a human society that might actually be sustainable as a plan for recovering an HSS.

As with any CAES embedded in a larger meta-system, the HSS will need to meet a set of criteria for success in order to be long-term sustainable (Mobus, 2017). As outlined in the reference these conditions are:

1. Fulfil a purpose – produce valuable outputs
2. Receive rewarding (essential) inputs
3. Be adaptable

4. Be evolvable
5. Be lucky[1]

The first condition is a statement about the fitness of a CAES, we brought this up in Chapter 13. The supra-system is comprised of many other systems entities that may cooperate with or compete with the system of interest, in this case the HSS. If the HSS produces one or more outputs that are of value to the Ecos as a whole, then cooperation with those other entities leads to stability and rewarding feedbacks.

Systems Design for the Human Social System

Here we will tackle the most important and easily argued most difficult (complex) design task put before us, the design of a more systems-rational social system for humanity. We do not assert that what we present here is THE design. Rather what we present below is more on the order of design challenges, but with hints of how those challenges might be pursued given the systems archetypes for CAESs.

As discussed above, the design of a system starts with the knowledge captured in the knowledgebase, per Chapter 7, as a result of having done a deep systems analysis, per Chapter 5. Here we run into a peculiar situation. The HSS already exists. Moreover, the various social sciences have already uncovered significant normative knowledge about human behaviors, especially with respect to their proclivities in being agents, the economic systems that are extant in the world, and the various forms of governments also extant in the world. We could hypothesize that if all of the knowledge thus far gained could be realigned with systems principles and theories than the knowledgebase needed for modeling and design would be at our finger tips. The presumption might be that all we need to design are 'interventions' that would mitigate, correct, or otherwise replace faulty functions in the current social system.

Considering the Current Realization of CAES Subsystems

However, intervention is not a real option. The current realization of the HSS is so far from the fundamentals of the archetype sub-models of the CAES that the likelihood of finding the right intervention or leverage points is next to nil. Recall from Chapter 8 that we used deep systems analysis to understand the economic subsystem (or at least an important piece of it) and discovered several disturbing pathologies with respect to how the nature of the neoliberal capitalist world view, coupled with beliefs in a 'free market' and unlimited profit motives are

[1] There is good reason to believe that the Universe is fundamentally non-ergodic. That is, at each instant the Universe enters a new state of existence and passing from a prior state that it will never enter again. Thus, all processes and phenomena are fundamentally non-stationary with respect to the relations between existing systems. This being the case, there is never any guarantee that an ultimate stable and persistent condition will ever obtain. Long life depends on the environment of the system to remain sufficiently stable that adaptation or evolvable reconfigurations will sustain it. That is not a given, hence, the system relies on a certain amount of luck. Massive, overwhelming changes, such a being struck by a comet or meteorite, are always possible.

acting more like cancers than healthy sustainable economic activities. As another example, from Chapter 12 we learned that the role of a 'currency' in an economy is to control the flow of energy available to do useful work. But, as mentioned in Chapter 8 we saw how the monetary system in the modern market economy has almost completely lost this role, being treated as a commodity (Ferguson, 2008; Polanyi, 2001) rather than a standard measure of work potential[2]. The result of this loss of true information about the operating health of the underlying work processes and distribution of produced wealth has resulted in uncontrolled oscillations in the economy as a whole.

These examples of dysfunction, or rather loss of healthy function in the economy, are just one aspect of the complete social system and if we were to do a similar analysis of the governance systems actually in use, we suspect we would discover many other dysfunctional aspects[3]. Indeed, the argument that governance and economics are strongly coupled subsystems, as was done in Chapter 9, leads us to conclude that both systems are deeply flawed with respect to achieving sustainability for the HSS in a long-run.

On top of that, we have to take note of the distance from perfection of the agents[4] that operate in both systems – human beings. Even the best intentioned and smartest, most knowledgeable humans are prone to make mistakes in judgements. Most are still subject to hidden biases and worldview beliefs that cloud their capacity to see the relevant situation and conditions that require veridical decisions. The higher one goes in the governance infrastructure of a large organization or government, the more damage they can do via errors in judgement or dishonesty. We will take a brief tour of the main deviations from the model archetypes developed in Part 3.

In Chapter 6 we provided a preliminary top-down analysis of the human social system, starting with the embedding Ecos (whole Earth and particularly the biosphere). Now, using the

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[2] The Gold Standard adopted by many nations seeking to participate in the international market served as a kind of standard for the creation of money. There were, however, still problems with using a non-intrinsically valued metal – excepting perhaps for its ornamentation value – to represent the value of work and assets produced. See the two references for analysis of these problems. The standard was abandoned for a time due to these problems and reinstated after WWII until the United States abandoned it as a basis for printing money. Now the different national currencies relative values float on a commodity market and the relation to actual production potential is lost.

[3] This is almost a laughable understatement as of this date (September, 2019). National governments all over the world are easily seen to be dysfunctional. Some of this is due to the inherent inconsistencies in their designs (with respect to the governance archetype) so are endemic to the systems. More and more, however, we can see the dysfunctions with respect to those of the agents themselves – human beings – as corruptible and greedy.

[4] See the discussion of perfect decision agents in Chapter 10 [Ideal Agents]. Human decision makers, even when rightly motivated to make good decisions for the benefit of the system, are still plagued by a number of faulty factors such as incomplete or noisy information, lack of computing resources, and insufficient time. Then on top of that add psychological factors such as greed, desire for power, and hubris (among others) and we quickly realize that human decision makers at the heads of major corporations and governments are generally found to be far from perfect agents.

methods of Chapter 14 we will provide a preliminary design. First, however, we need to understand why the current realization of the HSS as a CAES is far from ideal.

From the CAES Archetype – Purpose of the HSS

As noted in Chapter 6 the current realization of the HSS is fundamentally flawed as a CAES because it has no real purpose with respect to serving the good of the larger embedding supra-system, the Ecos. The human economy does not produce a product that serves the needs of other subsystems or the whole. Instead, the HSS as currently instantiated seeks to serve only its constituent members seen as 'consumers' without regard to the larger Ecos. It extracts, forcibly, natural resources at a rate that exceeds their replacement, in stocks, or their feasibility in flows. And, the HSS produces by-products that are effectively toxic to other subsystems at rates that exceed the ability of the Ecos to denature them. Plastics, in particular, but also a number of chemicals such as drugs and biocides, are proving to be poisoning not only other life forms, but humans as well. In its current form and function, the HSS is a blight on the planet.

The first question our analysis needs to ask is: Can there be, or should there be, a purpose served by humanity that supports the Ecos and its long-term sustainability as a living system? In sections below we attempt to answer this question in the affirmative. We will assert that a society of human beings, systemically conceived and instantiated, can fulfill a role for the planet very much *similar to that filled by the brain* for individual beings. But for this to become a reality we need to grasp what the various deviations from the CAES archetype are. We address this overarching flaw in sections below.

From the Economic Archetype

In Chapter 8 we discovered a number of deviations in the form of a systems economic architecture in the way the current neoclassical, neoliberal capitalistic economy fails to account for biophysical realities such as energy and other finite resource limitations on growth and profits. From Chapter 12 we saw that a systems-based economic architecture not only takes these issues into account it also explains why institutional views of things like "free markets" cannot be the full basis for a functioning economy for the HSS.

What we do now is ask what an HSS economy (and its governance) would look like if we followed the principles of systems science and utilized the lessons of natural CAS/CAESs in these archetypes. The central question might be posed as: "How can the HSS economic subsystem be architected/designed to meet the requisites of a sustainable HSS?" Recall from chapters 8 and 12, and as stated above, that a sustainable CAS/CAES needs to produce an output that is useful to the supra-system – in this case the Ecos – and thus be rewarded by the supra-system providing sustenance to the CAES. The HSS is completely embedded in the Ecos, and until we figure out a way to abandon this planet for a better existence, we had better determine how to best fulfill our role of benefactor of the larger Earth system. The HSS economy needs to be organized so as to use resources at a sustainable rate, recycle its material resources, and not produce toxic by-products in the process. And it must serve a purpose.

The Economic Archetype shows us that our role in the Ecos is to take in a “reasonable” amount of resources needed to sustain our own existence and still produce an output (product and/or service) that benefits the Ecos. It also shows that our waste products must be recycled and/or usable by some subsidiary processes that can ultimately benefit from those wastes (and as a result recycle positive benefits to the Ecos).

We have seen how the economic archetype is a sequence of value-adding processes that use high-potential energy resources and high (or medium) entropic raw materials to produce consumable goods and services within the economic system but also output useable products or services to the supra-system. Previously we noted in Chapter 8 that, currently, the HSS does not really produce anything of benefit to the Ecos. And, indeed, to the contrary, produces unrecyclable wastes and consumes all available resources to the detriment of the biosphere. The systems view suggests that this is unsustainable. How, then, should we design an economic system that is capable of supporting the HSS and be integrated with the Ecos? In sections below we will attempt to show how to begin answering this question.

From the Governance Archetype

The economic subsystem is strongly coupled with the governance subsystem. The latter is, of course, more than just the regulation of economic activities. It includes judicial oversight on misbehaviors as well as interpretation of, and enforcement of agreements (contracts) between transaction partners. But the architecture of the governance subsystem is coupled with the architecture of the economic system so we must look at how this is accomplished.

The objective of this aspect of the governance subsystem is to ensure that the economic subsystem operates cleanly and efficiently. The governance of independent entities within the economy has been adequately covered in Chapter 11. In this chapter we focus, rather, on the coordination aspects of how multiple economic entities within the HSS can be seen to cooperate or compete without damaging the overall HSS economic subsystem. That some form of coordination, and indeed, some form of strategic management, is needed to make a large-scale economic system work will be unwelcome to some worldviews of economics (and human proclivities) is foreordained. But if we stick to a systems perspective (and keep open minds regarding the significance of the findings) we may come to see that some ideologies are misplaced with respect to the optimal operation of an HSS economy (and its governance)[5].

The problem with the current political process – the process for choosing how we are going to be governed and by what principles – is that it has largely devolved into a highly divisive kind of popularity contest and has been deeply corrupted by the intrusion of market-based thinking

[5] Specifically, we refer to liberalism and libertarian sentiments that espouse a minimal role for governance in economic activities and social lives. Put bluntly, these are worldviews that are contrary to a systems perspective.

(i.e. money as it is currently understood) rather than being a process of reasoned collective decision-making (c.f. Brennan, 2016). Thus, from the outset we point out that while the design of a functional economic system, filling the role of metabolism for a society, is completely feasible following the systems approach, it cannot yield success without simultaneously redesigning the political process to match.

And none of these can be successful without a systems approach to governance. As delineated in Chapter 11, a governance subsystem that fulfills the purpose of regulating a CAES from within is possible and, for purposes of sustainability, necessary. Translated into more common terms, this means that an HSS governance superstructure needs to be designed based on the hierarchical cybernetic governance model – in effect a new kind of constitution needs to be drawn up based on systems principles. Then the political process (subsystem) can be designed to select capable agents to fill the governance positions as described in Chapter 11. This would definitely not involve political "parties" driven by political ideologies, but rather be akin to public debates over substantive issues that would need to be addressed to keep the governance subsystem functioning in light of whatever changed environment the Ecos has become.

The potential design of a governance subsystem has been covered in Chapter 11. A political subsystem designed to select the agents to operate in that subsystem is, unfortunately, more than can be covered in this book. We are left to assert that such a co-design, with the economic subsystem, would be necessary in order that the latter would succeed. Our objective in this chapter is to show how a systems approach to the design of an important subsystem of the HSS might be approached and to offer insights into how such a design might lead to an exo-metabolic process that would keep the HSS being a productive, purposeful, subsystem of the Ecos. We will, for the time being, assume that the co-design of the political process is accomplished apace. In other words, for the moment, we will, for the moment, assume that a process that selects capable decision agents in the governance structure, as it pertains to economic matters, is a given. Later we will consider the more realistic case where less than perfect decision agents are emplaced in positions of responsible decision-making.

From the Agent Archetype

The most difficult factor to approach in the design of a well-functioning HSS is the human mind as a decision agent. Classical economics required that human beings are rational decision-makers, *Homo economicus*[6], that is they make economic decisions in their own best interest. But in the new field of behavioral economics[7] the evidence has been amassed that shows humans to be 'victims,' as it were, of biologically-evolved biases and using heuristic thinking that is

[6] See the Wikipedia article: https://en.wikipedia.org/wiki/Homo_economicus for background. Accessed 11/18/2019.

[7] See the Wikipedia article: https://en.wikipedia.org/wiki/Behavioral_economics for background. Accessed 10/15/2019.

"rational" in the context of making fast and mostly useful decisions in the world of the Late Pleistocene but fails to provide sufficient guidance in modern complex situations (Gilovitch, et al. 2002; Kahneman, 2011). This is just one of the many theoretical bases that neoclassical economics gets wrong but it is possibly the most important error. Human cognition is evolved to deal with survival in a world of social dependence and support; as Polanyi (2001) points out, human beings were not individuals competing in a "labor market" and weren't subjected to becoming a commodity until the dawn of the Industrial Revolution. They were members of a collectivist society which worked to produce the subsistence necessaries of life. Social agency and economic governance were one and the same, in a sense. Working and relating in a tribal-like group were all part of the same process of living. And human agency prior to the Agricultural Revolution was adequate to the needs of decisions that needed to be made.

The ideal agent computes a decision based on a model and, possibly, a knowledgebase of both explicit and implicit knowledge (Mobus, 2019). Unless an environment is shifting rapidly such decisions would tend to be reasonably good (veridical and sufficient). There are no guarantees of absolute correctness, of course. There are always problems with, for example, communications or sensor noise or data occlusions that reduce the validity of any given decision. But such an agent is not motivated to cheat or deceive other agents. Humans, unfortunately, seem to have this problem. It is likely that a good part of possessing non-pure motives is the fact that in the modern world (and for some many centuries now) humans have been subject to inordinate psychological stress that acts to increase the noise level. That most certainly can explain part of the problem. But at the same time, humans, as mentioned at the start of this chapter, seem not to have evolved an adequate cognitive capacity for gaining and using wisdom (see more discussion in the next section). A chief component of the psychological construct of wisdom is strategic thinking, a mode we seemed to be heading toward as a result of group selection operating on the brain's capacity to obtain and use implicit knowledge of how the world worked to make judgments about how to handle complex social problems (wise grandparents and tribal councils). We have asserted that it is the lack of adequate wisdom learning that is at the root of poor decision making in the modern society (Mobus, 2019).

Regardless of the mechanisms involved, humans are notoriously non-humane in making both economic and social decisions, tending toward corruption and abuses of power positions to elevate their own wealth and status. It might go without saying that the current implementations of both economic and governance designs, even if they were closer to the archetype models, would necessarily fail just due to the "human factor" alone. Fortunately, there may be a way to circumvent this conclusion. Humans might be expected to do much better at decision making under the right conditions. This will be a major design consideration as we proceed.

Why the Deviations?

How many thousands of history and psychology books have been devoted to wondering why our present world is the way it is? Many, many authors have wondered why. Many philosophers have questioned the nature of humans and why our evolving civilizations have followed the paths they have; civilizations have come and gone and recent finds in archeology suggest there are underlying similar patterns to the process of growth and decline/collapse (c.f. Diamond, 2005; Harari, 2011; Homer-Dixon, 2009; Tainter, 1988).

In this section we will provide a synthesis of some of the major ideas that have emerged in recent decades that provide a more systemic view of why our current world civilization is so dysfunctional.

Human Evolution – Toward Wiser Beings

There are strong reasons to believe that humans were evolving into hyper-social animals some 180-200,000 years ago (Donald, 1991; Gazzaniga, 2005; Nowak & Coakley, 2013; Sober & Wilson, 1998; Tomasello, 2014, 2016; Wilson, 2012) when the modern version of *Homo sapiens* emerged in East Africa. Furthermore, evidence suggests that what made humans sapient (according to Carl Linnaeus[8]) is their capacity for making wise choices. The full nature of sapience is provided in Mobus (2018) but includes conscience (or moral sentiments), tacit knowledge-based judgement, systemic, and strategic thinking. Humans are the first animal to display a capacity for genuine strategic thinking.

This is to say that the evidence for humans becoming better decision agents evolutionarily suggests that they were on an evolutionary trajectory toward becoming wiser beings, likely by virtue of being hyper-social. The subject is far beyond the scope of this section, let alone chapter, but it is an important part of the pivotal argument. Mobus (2019), Chapter 5, provides a more comprehensive set of arguments regarding the evolution of wisdom capacity in early humans prior to the discovery of agriculture.

The nature of human societies and concepts of household and tribal 'economics' and 'governance' before the advent of the agricultural revolution and the transition to early civilizations was much different than has evolved culturally since (c.f. Scott, 2017). However, the argument from social psychology is that human cognition is essentially the same as it was in the Late Pleistocene so that our modern cultural innovations, begun with the revolution and elaborated into the present, especially large-scale societies, are anathema to human mental well-being. That argument is likely cogent with one exception. Mobus (2018, 2019) has argued that the agricultural revolution and the subsequent inclination to settlement life brought about an end to the selective forces favoring increasing strategic thinking. Emphasis, instead, was on logistical and tactical thinking, which had unfortunate consequences for the further coevolution of humans and their cultures.

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[8] Carl Linnaeus (1707 – 1778) gave us the Binomial Nomenclature system of naming species. His choice of 'sapiens', meaning 'wise' might be considered suspect in light of choices humans tend to make. See the Wikipedia article: https://en.wikipedia.org/wiki/Carl_Linnaeus for background. Accessed 10/7/2019.

Agriculture and the Re-emphasis on Logistic/Tactical Thinking

Humans evolved as groups/bands of hunter-gatherers a life-style in which there was an emphasis on strategic thinking to anticipate the locations and timings of game and plants, especially in the face of other groups would be doing the same. The travels of a group depended on considerations of the resources to be gained and in terms of competition for those resources. This was not dissimilar to the strategic moves of a chess game. And it had been the main selective pressure on humans up until they became much more dependent on agricultural produce and animal husbandry. This required a stronger attachment to a specific area and led to more settled life. The domestication of plants and animals and the living style required thus lessened or even removed the need for strategic thinking.

The agricultural revolution was the first time that humans consciously sought to manage the acquisition of energy and physiological matter (food) as opposed to simply searching for it. Humans, as all animal life, had always been dependent on solar energy but had not previously sought to ‘regulate’ its acquisition and storage (Crosby, 2007; Scott, 2017). With the advent of horticulture humans were able to seriously reduce the uncertainty associated with hunting and foraging. But it required a different set of thinking skills oriented toward logistics (preparing fields, planting, cultivating, harvesting, etc. and their seasonal timing) which were managed by a small segment of the population. The majority were engaged in the labor of growing, harvesting, and preparing food. Human numbers increased in settlements and the need to organize and manage labor led to the hierarchical arrangements that we still see in today’s governments and organizational management. These needs led to a new way of communicating as well – the systems of writing and numeracy that grew out of simple marks on clay jars (Nissen, Damerow, & Englund, 1993).

In the rise of agricultural-based societies, humans didn’t just domesticate plants and animals. They domesticated themselves (Scott, 2017).

This new living style also led to conflicts between settlements and the remnants of nomadic hunter-gatherers, raiders, who found the settled peoples easy targets. The need for tactical thinking developed, the heads of the hierarchies had to not only manage agriculture they had to take responsibility for protecting what they had.

So, starting about 10,000 years ago, humans became socially organized into pyramidal strata. Workers at the bottom of the hierarchy needed only operational thinking skills, managers in the middle needed mostly logistic thinking skills, soldiers and their leaders needed some tactical thinking skills, and chiefs on the top needed occasional strategic thinking skills. Note that the majority of the population has been at the bottom of this structure ever since, and by the logic of evolution and selection for the specific thinking skills needed at these levels, humans have, on average, been tending away from average capacity to think strategically and toward the more immediate thinking needed for solving little and local problems of operations (Mobus, 2019).

While this argument may carry a fair amount of weight in terms of explaining a lot about current human psychology (specifically a broad lack of wisdom) ten thousand years is a short time in evolutionary terms. It is not yet the case that humans lower in the social hierarchy have lost all capacity for, say, tactical and even some strategic thinking. But it is likely that these capacities are greatly diminished from where we were as a species in the Late Pleistocene[9].

The irony is that in a complex rapidly changing environment the need to make logistical, tactical, and strategic decisions is greater. The current global civilization has come about in a few hundred years after the discovery of the use of fossil fuel (coal) and the heat engine coupled to machines – the Industrial Revolution. This is a time scale far too short to allow selection for these thinking skills to re-emerge. Hence, we find human decision-making generally inadequate for the needs of this environment. The general result is that most people, when faced with a complex situation needing some kind of decision, resort to guessing (gut reactions) and faking competence.

Technology, Convenience, Power

The use of technology to perform work and solve problems has always been a two-edged sword. Starting with the use of fire to spook game into snares, to cook food for extra calories, and to shape the landscape in favor of grasses, humans are unique in their ability to control external energy to do work (c.f. Harari, 2011, p 13-14) perhaps 200,000 years ago. With the development of stone implements (even earlier) humans gained the advantage of leverage (e.g. skinning the hide from a prey animal and butchering it). Recall that in Chapter 8, section 8.5.2.1. “A Note on the Meaning of Tools,” we explained this in the context of the physics of economy. Tools make life easier, increase efficiency of operations, especially the gain of calories, and give human users increased power to dominate.

Tools, in all their various forms, are part of the fabric of culture, which includes collective beliefs and various institutions. All of these latter are, in some sense, also tools in that they help increase the effectiveness and efficiency of human activities. Whether those activities are ultimately beneficial to the whole of society may be questioned, of course. The old saw, “The right tool for the *right* job,” might be invoked. A systems analysis of what the job is, meaning looking at the products the job produces, would include determining the worthiness of that particular activity.

It isn’t too outrageous to claim that humans are spoiled and have become more so over several centuries. Over the course of the Industrial Revolution, in particular, the culture has progressively moved from mostly utility considerations, such as having the willingness to ‘darn

[9] It should be pointed out that the same selection forces, or lack thereof, was not the case for peoples still engaged in hunter-gatherer life-styles. The numbers of such people far exceeded those in agricultural-based societies for much of the history of the species. However, in terms of differential reproduction rates, domesticated humans out paced the non-domesticated. And over the last several centuries, especially due to colonialism, domestication has spread to nearly every corner of the globe.

socks' to keep them in service, to the desire for convenience; now we throw the socks away when they get threadbare. This is partly from the fact that consumed goods have, relatively speaking, become cheaper as the capacity to manufacture and the availability of cheap energy has increased through technological innovations. But it is also partly from the attitudes of people who we now call 'consumers.' People are expected to consume, use up, and replace rather than conserve and repair. The modern manufacturing process assumes continuous consumption, designs products to effectively not be repairable, and all so that sales don't sag.

The continuous throughput of material can only be sustained by the continuous, and often wasteful, use of substantial power flows. Moreover, in a growing population and increasing individual consumption habits, the amount of power consumed has to increase.

Technology is always a two-edged sword. It may provide convenience to individual consumers but at the cost of externalities that end up impacting society as a whole.

The Modern Conundrum in the Social-Political-Economy

There is a strongly held belief in Western nations that a free-market economy is self-regulating through the price adjustment process under the forces of supply and demand. Polanyi (2001) described the history of the emergence of a market-based economic model at the time and in conjunction with the emergence of a higher-powered industrial economy in England in the late 18th and early 19th centuries. Adam Smith (1723 – 1790) famously observed, in "An Inquiry into the Nature and Causes of the Wealth of Nations" (1776) that merchants, craftsmen, and other participants in economic exchanges performed their works and traded cooperatively and that the whole affair was guided not by government intervention or control, but as if by "an invisible hand." Each participant, he concluded, in following his own self-interests (in making a living), pursued a course of action that tended to optimize the production of wealth for the whole society. This has been interpreted largely as any economic agent, following his own selfish desires, somehow makes life better for all. This is the basis for the notion of maximizing profits. It is the argument advanced to justify markets, their failures from time to time, and the accumulation of excessive wealth by capitalists (Piketty, 2014).

At least a part of the reason that people are inclined to believe in the self-regulating market as the best way to conduct economic business is that history is replete with examples of human agents in governing positions, with respect to economies, making tremendously unwise decisions, either from ignorance, stupidity, or malevolence (e.g. greed and corruption). If humanity cannot trust itself to govern an economy, the network of extractors, producers, and consumers, because its agents, no matter how being in a position of regulation, are prone to corruption, then the idea that a market can regulate itself for, if not optimal, then reasonable results is quite easy to adopt. The problem is that the complexities of HSS economies, along with the dysfunctions noted above, make the price mechanism an unreliable method of comparing values.

Put simply, humans can't trust money, prices, most institutions, and especially other humans in the modern conundrum.

A Future?

If the current situation of the HSS is untenable then what is to be done? There is a very good argument for our global civilization to collapse as a result of the many dysfunctions in economies and governance (Homer-Dixon, 2006; Tainter, 1988)[10]. What if we had a clean slate on which to design a functional HSS on the basis of the architecture of a CAES? Could we then design a workable, sustainable HSS? In principle, yes.

Here is the strategy.

All of our sciences, particularly the social sciences, medical sciences, psychology, anthropology, etc. have already acquired considerable knowledge about the human condition but it exists in disjointed structures, books, journals, and education curricula. Employing the method of deep analysis (Chapter 5), and organizing the information already made available in all of the sciences into a global knowledgebase (Chapter 7), we would be able to discover the holes in our knowledgebase. Much as 19th and 20th century chemist used the periodic table to 'predict' the existence of yet undiscovered elements, we could identify the areas of knowledge of humanity that needed exploring through further analysis. In many ways this process is already underway in some key areas. For example, neuroscience and psychology are becoming more integrated by discovery of correlates between neural activities in the brain with cognitive and affective mental states. This became possible with the advent of a structural framework (macro- and micro-anatomy of the brain) provided by network analysis (Seung, 2013; Sporns, 2016) that gave researchers a way to organize knowledge about neuronal and neural network functions. This process gives us confidence that with the right structural framework all of human knowledge, to date, can be organized and understood. This is what can be accomplished with the application of systems science and the language of systems.

An Architectural Design for the HSS

If we were starting from scratch, what kind of social system would we design? Imagine that humans, toward the end of the Pleistocene, had further evolved their capacity to acquire and use veridical wisdom, that when they discovered the methods of agriculture, they did not unquestioningly simply expand their numbers and start massive acquisition of natural resources. Imagine further that humans reflected on what they were doing and noticing how their activities impacted their environments. Of course, this isn't what happened, obviously. But if it had, what kind of society would befit human beings and benefit the Ecos as a subsystem?

In Chapter 6 we spent no small effort and space to the description of the analysis of the brain as a representative CAES. That effort was in anticipation of this chapter. Consider some

[10] This is especially relevant given the threats of climate chaos and energy depletions.

interesting isomorphic “resemblances” between neurons and human being, and between networks of neurons and networks of human relations, and between the information processing capabilities of the brain and that produced by the larger network of human interactions. The brain might be described as a network of functional modules, each a network of networks (e.g. the cortical columns), responsible for computing relevant inputs in coordination such that the organism is aware of its environment and produces responses (and plans) that support its existence tactically. Neurons are the main computational and memory trace encoding components that participate in a more global computational process resulting from the ways in which the modules and sub-networks are interconnected. Human individuals in a society also participate in global computations, though, obviously in far more complex ways.

Here we propose an approach to a model-based design of a human social system architecture that could, in principle, be fit in the context of the whole Ecos and provide a valuable service to it as one of its subsystems. The archetype model is, of course, the CAES described in Chapter 9. More specifically, however, we propose that the architecture of the brain provides the scaffolding for elaborating a design for humanity. We will describe that scaffold below as a basic model framework and then apply some of our system design approaches outlined in the last chapter to develop more specific suggestions as to how to proceed.

Society

It is probably a good idea to start with what we know about the nature of human social units in the late Pleistocene since this was considered a natural state that had been a part of human evolution. Specifically, we know that humans formed small groups, extended family and non-related members, numbering up to around 150 to 200 individuals of all ages. In fact, much of human evolution of the language and planning facilities are owed to a process of group selection – cooperation within a group and (sometimes) competition between near neighbor groups (Bourke, 2011; Buller, 2005; Calcott & Sterelny, 2005; Coen, 2012; Deacon, 1997; Donald, 1991; Geary, 2005;Harari, 2011; Mithen, 1996; Sober & Wilson, 1998; Tomasello, 2014; Westneat & Fox, 2010; Wilson & Sober, 1994; Wilson & Wilson, 2008; Wilson, 2013). Group selection operating on a population in the context of the Late Pleistocene was putting favor on groups that had members better capable of strategic and systemic thinking (Mobus, 2019).

It was only after the advent of larger-scale agriculture, particularly when the need for irrigation arose, that groups began to coalesce and expand in numbers (Scott, 2017)[11]. Settlements turned into large villages and some of these turned into towns. Civilizations arose as populations increased and agriculture demanded societies to become organized around the labor

[11] The pattern of forming settlements organized around the growing of grains or similar staples may have started in the Middle East (the Fertile Crescent) around 10,000 years ago but was repeated in other regions of the world independently. We infer that the form of the new kind of social organization that developed and was fundamentally the same in these regions was a natural consequence of the needs to organize society around the agricultural mode of life.

and management of it and land. Within the span of only a few thousand years the human social system went from small group dynamics to large metropolitan interactions. Humans are adaptable beings, but adaptation does not mean peaceful accommodation. Population densities convey stresses that may be adjusted for, but not relieved. The story of domesticated and crowded man is not one of simple adaptation. It is one of accumulating mental stress and the emergence of bad behavior.

Suppose that we reverted to a group size and organization that resembled the Pleistocene social module. Suppose that we organized societies to minimize population density stress. But also suppose that we carried forward our hard-won knowledge of how the world works, how we work. We might be organized in tribal bands, but not ignorant of why this form of organization is beneficial to our psyches. We will pursue this idea below when we get to the actual design of a social system. For the moment we note that that design is based on a hierarchy of social modules, with the basic module, a domicile, and an aggregate of a small number of such domiciles creating a community module. Higher level modules involve the hierarchical governance architecture.

Economy

The basis for an economy of society is the acquisition of necessary resource, food, shelter, clothing, etc. The economy is the means of producing two basic forms of wealth. The first form is the wealth that directly supports human life, of course. The second form is the wealth that is exported to the Ecos; the economy must produce a product that makes it worthy of being a subsystem of the Ecos. We need to use the economic archetype model to design an economy for human society that fulfills this requirement.

Considerations for such an economy include the necessity of not overexploiting resources and not overproducing wastes that cannot be processed by the Ecos so as to not become toxic. Ideally, all outputs from economic activity would be beneficial to some part of the Ecos, just as biological wastes, feces and urine, for example, are resources to decomposers.

Each social module will have an economy designed on the basis of its level in the hierarchy. The domicile module will be the basis of work processes with emphasis on operational management. The community module will act as the primary level at which a CAES economy will operate. Higher modules will be supported, economically, by the community modules and their purpose is primarily coordination management.

Governance

Below we will describe some details regarding the implementation of the HCGS architecture explained in Chapter 11. The governance of a human social module requires some specific elements beyond the plain vanilla version of the governance archetype described in that chapter.

Here we note only that the governance of this new concept of a social module is deeply intertwined with the management of the economic activity and includes a reflexive governance of the decision agents – people – who make decisions outside of the economic subsystem sphere that, nevertheless, have impacts on every aspect of the society.

Technology

What makes human cultures significantly different from other animals is the presence of tools and other objects that are the result of technological development and their use is the economy of resource acquisition, production, and consumption. In the kind of HSS to be described below we want to emphasize that the kinds of technologies that will be applicable will be limited in terms of their energy consumption (i.e. electric motors) and employed only in higher priority work processes. As will be explained below, technologies such as computing and communications may serve an important role in managing the whole HSS and it fulfilling its CAES purpose vis-à-vis the Ecos.

Otherwise we envision that most technology will be focused on the improvement of manually operated tools that will be used to do most of the work in the economy.

Designing a Human Social System as a Complex Adaptive and Evolvable System

In Chapter 6 we began the top-level analysis of the HSS (recall Figure 6.17). Then in Chapter 8 we further analyzed the existing economic subsystem, at least insofar as the energy acquisition and conversion to free energy was concerned. That analysis revealed some serious deficiencies in the current fossil fuel-based industrial economy. In both of these chapters we mentioned problems with current forms of governance, especially of the economy and especially with respect to humans as agents.

Then in chapters 9 – 12 we introduced the archetype CAES model and its primary sub-models, agents, economies, and governance. These, we claimed, are found in naturally evolved complex systems such as living systems from cells to ecosystems. We also made the claim that society is a CAES in formation through a combination of auto- and intentional-organization and that the problems that the HSS has experienced were the results of insufficient knowledge had among the human designers of historical experiments in social systems. Put simply, the search for an ideal society has been based on best (not always good) guesses about how a society might achieve a stable, resilient, and persistent existence. That search started in ignorance of systems principles and led down many a blind (and destructive) alleys.

Now, knowing considerably more about all of the various components of human nature and the sciences that gave us our modern technologically-based culture, might it not be possible to suggest the way forward in designing a true CAES-based human social system? In this section we seek to start that process. It should be obvious that one author, in one book, could not hope to get very far into the analysis/design of a total system. All we can offer here is a glimpse of what that process might entail. Even so, we think the glimpse will be instructive. At some time in the future, when there is a body of systems designers who have taken the procedures and visions of this volume to heart, perhaps a full-blown deep systems analysis of the needs of a properly functioning HSS can be undertaken. In the meantime, here are several of the aspects of such a system we have considered.

Designing for Faulty Agents

Humans make fundamentally three kinds of decisions. One kind of decision involves interpersonal relationships and is largely driven by emotional/affective mental processes. These include the observation of social norms and commonly held beliefs, such as religious convictions. They are the evolved responses to living in social groups. We will not dwell on how these decisions are made or their consequences except to note that these kinds of decisions are driven by subconscious, affective factors that are subject to all kinds of mistakes (see Mobus, 2012, 2019, for a deeper analysis of affective decision-making).

Governance decisions are related to regulating social and economic processes. The former concerns laws, mores, etc. and their enforcement, acting as the explicit, conscious mechanisms overriding the affective-driven decisions just described above. Social governance attempts to reduce affective mistakes as well as extend the beneficial forms of interpersonal and social behaviors. The latter concerns operations of and coordination between work processes.

Economic decisions are related to obtaining resources and using them wisely, or should be. That use includes determining what products need to be produced to support human life and wellbeing. And decisions need to be made regarding how the produced wealth is to be distributed equitably in the population. As mentioned in Chapter 8, currently there is a widespread belief that something called the "market economy" somehow magically solves all of these problems effectively and efficiently. This belief persists in spite of the both theoretical (Polanyi, 2002) and empirical evidence (c.f. Keen, 2011, for explication) that this is far from true. Yet economic actors make decisions and behave as if it is true, and that is a fundamental problem.

As has been mentioned, humans as agents have some serious faults. When the nature of the overall system is relatively simple, small in scale, not involving too much technology, and does not involve the abstraction of "money" as wealth, then humans can be reasonably effective decision makers, as when they lived tribal lives in the Late Pleistocene. But, when the situation is as it is now, size scale beyond anyone's comprehension, technological and relationship complexities also not grasped by the average human, the capacity for veridical decision-making has become seriously compromised.

Thus, the design of any form of HSS must include serious simplification of the social milieu in order to greatly reduce the psychological stresses that lead to selfish, self-centered, defensive behaviors. This implies returning to a social structure based on small tribe-like units. We will further discuss this idea below in the section [Social Organization]. For now, we will simply note that human beings living and working in smaller groups do perform much better. Operating in much less complex social situations, they are far more prone to make decisions for the benefit of the group as opposed to for their own gain. Complex technological environments also press people into more anti-social behaviors. Observe the rash of on-line bullying among students on so-called social media.

While humans may behave better, and make more rational decisions in a simpler and smaller group environment, they are still capable of deviations from time to time. They are still able to make mistakes for a variety of reasons not just caused by stressful conditions. For a very long time now we have understood a basic concept of third-party auditing as a means to catch mistakes (or fraud) and report these to “higher management” or external enforcement to activate correction procedures. The audit function can be found in all natural CAESs. For example, in the maintenance of the genetic code in chromosomes, there are proteins tasked with monitoring the “health” of the strands of DNA. If an anomaly is detected, such as a point mutation in a somatic cell’s gene, an error correction mechanism is activated that repairs the site.

The design of an HSS governance system should include provisions for an audit function for all activities. For example, in our current system we need a policing function and a justice system to enforce laws relating to interpersonal interactions. Humans had evolved cognitive means for detecting dishonesty (cheating) in members of a tribe and retain these abilities today. The policing function we find necessary today was fulfilled by that system of auditing behaviors and public rebuking or expulsion from the group for guilty parties. The design of the human social unit should allow the re-emergence of this kind of audit function in interpersonal relations.

The problem of faulty agents in government has always been a problem in civilizations. Societies, especially in response to growing larger and more complex, evolved various forms of distributed governance. Even autocratic government found it necessary to offload various decisions to ‘underlings,’ particularly those involving more operational and logistical problems. Eventually the problem with faulty agents in positions of authority provided a selective pressure favoring what might be seen as the ultimate form of distributed governance that depended not on one agent in charge, but a collective of agents, a forum or a legislative body. Democracy is presumed to be a method for countering the effects of agents in power positions from abuses of that power. But it is found that democracies have their own problems when the right to vote is restricted to a non-representative set of citizens, or when the citizenry is largely ignorant of the governance issues and policies (Brennan, 2016). The more complex a society becomes the more the notion of egalitarian (liberal) participation in governance falls down. Yet the notion that governance of a social unit, a module of ‘reasonable’ size and complexity, should involve a plenum of members seems worth pursuing. In the design of life-critical control systems engineers often use redundancy to guard against failure of the system. For example, a troika of automatic (embedded) controllers use the same or similar sensor data to make a control decision. The rule used is that if two out of the three come to the same decision that is the one taken even if the third controller comes to a different decision. Critical decision points are handled by a council rather than a single all-powerful controller. It is believed this was the principle at work in the evolution of tribal councils. Below we consider this principle in the design of a social governance system.

Ultimately, given the psychological nature of modern human beings, there is probably little that can be done to prevent corruptibility. However, we suspect that actual corruption is propelled by cultural drives rather than a natural tendency for humans to be selfish and self-centered. It is our modern social milieu that promotes corruption rather than an overarching propensity to cheat and steal and lie (everyone else is doing it so why shouldn't I). Our thought is that given the design of a social system as described herein, where the systems at the modular level are kept simple and scaled to human capacities, the more dominant propensity of cooperation and eusociality will prevail. And while cheaters may always emerge, that they can be dealt with in the traditional fashions of shaming and ostracizing the culprit.

Designing a Sustainable Economy

The job of an economy is the production or acquisition of energy and material resources, the production of useful wealth, and the equitable distribution of that wealth. Just as importantly, however, the economy must export products and by-products to the environment. Internally, recycling as much as possible should reduce the output of waste products. All other work processes are ancillary. For example, the construction of farming equipment, requiring the extraction of metals, working them into shape, etc., is driven by the needs of food production.

However, as noted earlier, a CAES embedded within the matrix of a larger supra-system must produce a product that will benefit that larger system. That is what makes the system fit and ensure that the larger system will provide sustaining support (resources) to the system. Every CAES has a purpose. As previously noted also, the HSS currently does not produce any useful product for the planet. But that need not be the case.

We will, briefly, analyze the HSS as a sustainable, resilient, and persistent CAES.

Boundary Analysis

As recommended in Chapter 5 we will start with the examination of the boundary and the flows of energy, materials, and messages into and out of the system, and the environment, the sources, sinks, and milieu. Initially this involves the delineation of the boundary conditions, describing the human occupancy of the land and the interfaces between the HSS and the rest of the Ecos. These will include input/output interfaces. In the society of today these would include interfaces such as farms to capture solar energy and convert it into calories for human consumption and fossil fuel-burning processes (such as internal combustion engines) for output of carbon dioxide into the atmosphere. But what we seek in our utopian society are input/output flows that are in balance with the natural capacities of the Ecos to supply inputs and process outputs. As we will describe below, the HSS needs sufficient energy to support human life and activities. But the amount of power consumed cannot exceed the thermal balance with the Ecos. Essentially this means real-time solar input flows.

The boundary of the HSS is fuzzy and highly porous. For example, many of the potentially toxic chemicals we put into the environment are now being found in food and water supplies around the world; they are ending up in our bodies without any control. A seemingly clear boundary condition is that humans are a single species, so have essentially the same biological needs. But humans reside in domiciles (families) that include non-human components vis-à-vis vegetation, domesticated animals, and myriad artifacts. Each domicile will occupy some amount of space and with persistence for extended time. The collection of domiciles we will call a 'community' (to be detailed below) plus fields and connecting pathways can be similarly considered as the space that the HSS occupies and thus in the HSS. However, the physical boundary will vary in composition and extent depending on local conditions. In our consideration of what is in the HSS we shall take the strength of connections between human beings and the 'things' with which they interact on a more-or-less daily basis. We consider what is outside as the rest of the Ecos and natural resources that may be extracted periodically or on an as needed basis.

As demonstrated in Chapter 5, our boundary analysis should look first at outputs of the HSS and then the inputs. This will put us in the position of tracing the internal flows and processes that need to be in place to produce the outputs from the inputs.

Outputs of the HSS

Let us start with the output of a 'product,' that is, we ask what is the purpose of the HSS with respect to the Ecos and what product output would serve that purpose? What should that be and what other subsystems of the Ecos benefit? The brain-architecture mentioned above gives us something to consider. Pushing the analogy further, if the HSS is effectively operating as a brain for the planet, then the main output might well be expected to be the management of the planet (c.f. Grinspoon, 2016 for a perspective on this idea) in the same way the brain manages the body. There will, no doubt, be an immediate negative reaction to this notion. The argument will be that humans have failed to be decent stewards of the planet thus far, why should they now try to do so? The answer is that if the HSS is designed to be a sustainable CAES, employing a planet-wide HCGS subsystem (which is the brain-like aspect), then humans will have the social structure needed to be better decision agents (as per the section above regarding designing for faulty agents). Furthermore, implicit in this line of argument, we seek to design the HSS so that it benefits the planet.

Consider an example. The current HSS has the science and sensing capacity to monitor large parts of the Solar System, in particular the asteroids and comets that inhabit it. We have the capacity, presently, to compute the trajectories of many bodies that might be a threat to the Earth. And, though probably nascent in effectiveness we have some means for intercepting and redirecting any bodies that might threaten to collide with the planet and reek the same kind of havoc as with the End Cretaceous Event that did in the dinosaurs[12]. This would constitute the tactical management of the planet's interactions with other bodies in the Solar System.

As an example of logistical management, we have gained extensive knowledge of ecosystems dynamics and mechanics. We actually know what would need to be done, for example, to restore populations of plants and animals that have been decimated by human overshoot. However, in the long run, the planet had done a reasonable job of managing the logistics. The Gaia hypothesis holds that the biosphere has performed as both operational and logistics level regulators for maintaining the conditions of the other 'spheres' to support life (Lovelock & Margulis, 1974)[13]. It may be the case that once humans have helped restore balanced ecosystems that there would not be much needed in the way of management of the non-human systems.

Extraction of Resources – Inputs to the HSS

The HSS, as any real system, requires inputs from the surrounding environment such as energy, minerals, and forest products, among others. Farming provides a major source of energy flow in the form of food. Mining operations extract mineral resources.

We should assume that the extraction of fossil fuels will have come to an end, due as much to the low energy return on energy invested as to the need to not add any more carbon to the atmosphere. It is uncertain, at present, that photovoltaic or wind energy can capture any significant power, in all likelihood not enough to run our modern technological society. Dams and nuclear power plants actually require significant power to maintain. So, we are faced with a social system that must learn to live off of the real-time flow of solar energy primarily through a greatly reduced energy consuming agriculture[14].

The majority of the work to be done in these various extraction activities will be through manual labor, indeed, the vast majority of work processes will involve manual labor (or animal labor).

This fact need not mean that there could not be any technology. It isn't that a future society will need to revert completely to, say, a Middle Age feudal form. There are several different kinds of modern technology that would be useful to maintain and thus provide for some extra energy inputs (i.e. electricity). The communications capabilities of an Internet-like network would be near essential to maintain coordination between far-flung modules. In the arena of

[12] See the Wikipedia article: https://en.wikipedia.org/wiki/Cretaceous%E2%80%93Paleogene_extinction_event for background. Accessed 10/19/2019.

[13] See the Wikipedia article: https://en.wikipedia.org/wiki/Gaia_hypothesis for background. Accessed 11/13/2019.

[14] For example, permaculture. See the Wikipedia article: https://en.wikipedia.org/wiki/Permaculture for background. Accessed 11/12/2019.

agriculture, it would be useful to maintain some kinds of metal working (from recycled metals) for producing efficient hand tools and plows, etc. The vision of the early 19th century blacksmith comes to mind.

It isn't yet clear that solar photovoltaic energy extraction and conversion to electricity can effectively be self-reproducing (recall section 8.6.2.1 "An Exercise in Evaluating Solar Photovoltaic Capture and Conversion".) The same is even more true for wind turbines. However, in a society that does not demand as much electric power as our current western ones do (indeed, hardly any at all), and if solar panels in the future can be simplified and built primarily from recycled materials, it is conceivable that some form of direct solar energy might be viable. This is made more so if the production processes can be scheduled in coordination with the availability of sunlight, reducing the need for extensive storage[15]. As long as the electric power is reserved for powering the important technologies (e.g. communications) and self-regeneration, then it is conceivable that this form of real-time energy capture could be practical.

Production of Necessaries and Niceties

The model of the blacksmith may be thought of as a kind of archetype for the work processes that produce goods in a low-energy society; manual labor, skilled in various trades. The emphasis has to be on the notion of "necessaries." One can imagine a rank ordering in priorities from the preservation of foodstuffs without refrigeration or chemicals, to clothing, to housing, with supporting tool manufacture accompanying. What needs will be fulfilled will depend entirely on exosomatic energy production and the availability of free energy of sufficient power. As indicated above, for example, electricity production should be reserved for powering important (to society) technologies. Otherwise, the production of, say, clothing can be done completely manually using early 20th century treadle sewing machines similar to the one the author learned to sew on. Similarly, the production of fibers can revert to spindles, weaving on looms, knitting, etc.

A key to understanding the ability to revert production activities to manual labor, with late 19th century tools (with any improvements like saw blades sharpened to late 20th century standards) is that with a much smaller population not engaged in population growth, a much simpler lifestyle, and an economic system running on an as-needed basis, there is no need for continuous production at volume and buffering excesses (inventories). One model for this kind of economy is that of the Amish (and related sects) colonies in the mid-eastern USA. These German settler-derived societies have lived successful agrarian lives, eschewing modern

[15] The efficiency of both the solar panels and batteries is dependent on some rare or expensive materials and more complex designs. Real costs for these materials and manufacture are currently hidden in externalize costs rather than reflected in the price of solar energy, which gives the illusion that solar is more economic than it is in reality. Simpler, less efficient designs might mitigate these real costs but would obviously cause the cost per kilowatt hour to increase. There is a balance point between efficiency and sufficiency that needs to be investigated.

technology. So, we know that a much simpler lifestyle is not only possible, it is also likely to contribute to greater mental health[16].

The kind of economy being suggested does not mean ‘subsistence,’ or constant toil just to stay alive. Using our best knowledge of organic agriculture and production practices, and assuming social modules are situated in areas not hyper-adversely impacted by climate change-related calamities (e.g. the coasts), a reasonable proportion of living may be devoted to aesthetic pursuits – to niceties that enhance mental health and experiences of joyfulness. The objective of the kind of social system being described is to provide a modular environment in which individuals may achieve the higher levels of Abraham Maslow’s hierarchy of needs, esteem and self-actualization[17]. Early humans decorated cave walls with paintings, tools with adornments, and even created sculptures in clay. There is no reason to believe that this creative urging cannot be continued if the kind of social and economic milieu is much greatly simplified in the fashion being suggested here.

Recycling of Waste Products

Every CAES will produce outputs and the HSS is no exception. Ideally, those outputs are taken up as inputs to other entities in the supra-system or degrade to harmless materials. The rate of output flows must not exceed the rate of uptake or degradation, otherwise the intermediate products will accumulate in the environment and potentially poison some other processes.

To minimize the potential of accumulation, it is imperative that the HSS make every effort to recycle unusable but low entropy materials, such as scrap metals, glass, and building materials as well as high entropy organic wastes. In principle, the recycling of materials reduces the need for importing/extracting raw materials or the effort required in exporting wastes so the energy that might have been expended doing the latter input/output processes is better applied to doing the former.

Proper Role of a Market

We have established in chapters 8 and 12 that markets as generally understood in modern economics are only able to operate over short distances, when full costs of production are visible to all parties, and where speculative behaviors are disallowed. A CAES market is one where energy, materials, and messages can flow between near neighbors in a stable ‘price’ setting. Below we discuss the proper role of money as a signaling device, but here we point out that the use of money in a properly organized market is simply a convenient means of communication between buyers and sellers.

[16] See the Wikipedia article: https://en.wikipedia.org/wiki/Amish for background. Accessed 11/15/2019.

[17] Maslow’s famous model of positive psychology has been criticized on several counts, primarily as being overly simplistic. However it still represents an understanding that mental health includes things like self-esteem and the esteem of others in the group as well as a personal sense of being embedded in the world. See the Wikipedia article: https://en.wikipedia.org/wiki/Maslow%27s_hierarchy_of_needs for background. Accessed 11/17/2019.

In fact, nothing like our current concept of markets (e.g. financial, labor, real estate, etc.) can exist in a CAES-based HSS. The only markets that make sense are the kind that operate today in so many parts of the world; farmers' markets where food, clothing, furnishings, physical assets, and commodities can be exchanged. Money can provide a convenient mechanism as it does now, but the exchange value of transactions would be equal for both parties. A community market, for example, could provide a mechanism for exchanges between domiciles as well as a social 'event,' say once a week. It would be an occasion not just for exchange of goods, but of information and strengthening of friendships.

In a low-energy economy distance trading of various products would likely be limited to essentials that cannot be obtained locally within a module. This would operate at most scales, though with lesser volume as we go up the hierarchy due to the greater distances that need to be traveled.

The scale of any market is kept small by the modular and hierarchical design of the HSS. Transactions would mostly be point-to-point, that is buyer and seller, directly with an emphasis on eliminating so-called middle-persons (no wholesale or retail as we now know it). These mechanisms are generally seen as supporting a mass marketing, growing economy, which the CAES-based HSS would definitely not be.

Proper Role of Money

We have already made comment on the role of money in an economy, both in Chapter 8 (with a nod to the history of money) and in Chapter 12 regarding the economy archetype model. In the latter we argued that economic agents make decisions about acquisitions and production and signal those decisions, to suppliers or consumers, respectively.

At the level of metabolism there are various signaling mechanisms depending on the kind of work that needs to be done (say protein production at the ribosome) but a basic currency is the flow of ATP to the work process to supply energy and ADP back to the energy supply facility, the mitochondria. This constitutes both an energy flow and the signaling process itself in terms of requirements for additional energy flow. What causes the ribosome, as a work process and consumer of energy, to do its work in the first place is the receiving of messenger RNA molecules (mRNA) that activate the production of specific proteins. The DNA gene that codes for that particular protein, was, itself, activated to produce copies of mRNA by other signals from the cytoplasm generated because of a sensed shortfall in the concentration of that particular protein. In other words, there is a cascade of messages from the initial recognition of a deficit (or need) to the production center (ribosome) and then on to the energy supply center (mitochondria) that in the end controls the flow of energy and materials into work processes.

In bodily physiology there is a separation between signaling and energy flow (as well as material flow control). Various low-weight molecules, like hormones, are released and responded to in order to control the flow of energy molecules (e.g. glucose). The nervous system helps to coordinate the endocrine system signaling.

In the human economy of the modern world, the role of a signaling mechanism is taken on by money. At one time money was based on commodity value (e.g. the gold standard). But today that approach has been abandoned in favor of treating money as just another commodity (see Polanyi, 2001 for the historical record of this abandonment). A commodity-backed monetary system had the virtue of basing the amount of money, either fiat or bank-based, on the volume of value in the commodity. This helped to stabilize economic activity to some degree and facilitated market transactions. But the problem was the choices of commodities. When that commodity backing was based on the amount of grain (e.g. in barter systems some amount of grain could be worth the value of a cow) then there was a direct tie to the amount of energy (and matter) needed to support various work processes (basically food for human workers and draft animals). Later, after the introduction of precious metal coinage, the notion that the metal somehow represented, similarly, an amount of energy became very fuzzy. The metal started to take on a value of its own.

Today, with the advent of money-as-a-commodity with a floating rate of exchange, and with the advent of financialization of the economy (the equivalent of a casino) money has pretty much lost its original purpose as a mechanism for signaling to control the flows of energy and matter, and the work that should be accomplished. We will examine in greater detail what role money can serve in a human economy based on the archetype model.

Energy Standard Basis for Monetary Instruments

The production of true wealth, food, tools, and other productive assets, takes free energy. That is, energy that is of the right potential and kind (e.g. electricity) and flows at a sufficient rate (power) to drive the work process that transforms the inputs into outputs. The extraction and movement of raw materials, and the movement of products, i.e. all material flows, require the expenditure of free energy. Therefore, there is an energy equivalency of material available to an economy. In other words, all aspects of economic activity require flows of free energy.

We use this principle to suggest that the fundamental basis of economic activity is free energy itself. This corresponds with the original role of money in human economic activities. When a buyer pays for a product, they are signaling that energy should be applied to the production and transportation of that product. In this sense money is a form of information about the amount of energy that should be used for different economic activities. In effect, this is another form of commodity money (e.g. the free energy content of a barrel of oil). Rather than base monetary denomination value on an abstract notion of the worth of an ounce of gold, the monetary unit (e.g. a dollar) would be based on an amount of free energy measured in a common unit of energy such as the joule. This is justified on the basis that there is a direct link between the production of wealth and the availability of energy to do useful work.

The translation in monetary policy is straightforward. The ‘amount’ of money in units is exactly corresponding to the amount of free energy available to an economy. There can only be as many units of money (dollars say) as there are units of free energy backing that money. We can determine the amount of free energy available (from the raw energy resources in hand) from thermodynamics and engineering knowledge of the power requirements of work processes. The accounting systems we employ now would become meaningful in measuring true costs and revenues.

This has significant consequences for economies. In aggregate, the total production of wealth is tied to the availability of free energy. If, for some reason, the input flow of free energy declines, then the economy is, by definition, in a contraction; much less wealth can be produced. Contrariwise, if the flow of free energy increases, say due to an increased efficiency in extraction of energy from a flow-limited source, or just increased efficiency in the work processes themselves, then the production of wealth may expand accordingly.

Money, in this sense, is used to regulate the use of energy and the production of wealth for the HSS. The role of the governing process is to monitor the availability of free energy and regulate the money supply accordingly. Elsewhere, we consider the sorts of transactions that use token money (dollars) to affect those transactions. But the overall pattern is not dissimilar to what happens now (review Figure 8.14, the messages used to regulate flows). Two parties enter into an agreement to trade value (a product for a sum of money) but the price is determined by the energy control transfer. The buyer agrees to pay an amount of money equivalent to the emergy value[18] of the product, plus, possibly, a small increment representing a use or esthetic value premium (that which is known presently as 'profit'). Below we will discuss these values and their relations to energy flows.

Measure of Values

A key part of economic theory (including neoclassical economics) is the notion of value of an asset. In Chapter 12 we noted the idea that a 'tool' has an inherent economic value because it allows the user to increase the availability of free energy to a work process by virtue of reducing the total amount of raw energy needed to accomplish a given task. The tool, therefore, has a value that exceeds its emergy value (the amount of energy that was required to form the tool). Here we will explore several aspects of the basis of value to 'users' that contribute to variations on what 'price' a buyer might be willing to pay for an asset. This is important since a price system needs to incorporate the total free energy flow in the whole economy. The 1st and 2nd Laws of Thermodynamics demand it.

Base Cost to Produce

As mentioned above, emergy is a measure of the amount of energy that was consumed in the production of an asset. If the monetary system of an economy is based on energy then this

[18] Emergy, a term introduced by Howard Odum, is the 'embedded energy' in a low-entropy material object, that is, the amount of free energy that was used to produce the object. See the Wikipedia article: https://en.wikipedia.org/wiki/Emergy for background. Accessed 10/22/2019. Odum developed a complete energetics model of the economy. See Odum, 2007.

represents a base cost of production. It is a starting place for assessing the value of an asset product. The producer must add up all relevant energy costs including labor and externally supplied energies. Presumably the labor costs include the producer's own energy (that is their energy uses to do the work but also to support their own family). All free energy inputs to the production process should be considered. These form the basis of computing a true cost in monetary units and set the basis for a price to be used in establishing an archetype market price for the asset. Essentially this is similar to Karl Marx's and David Ricardo's "labor theory of value[19]," except that the actual work processes in production today rely on machinery using high-power energy and are merely controlled by or augmented with human labor.

The base cost is just the first step in establishing a fair price in an archetype economy market. Premiums for the extended value of a product might be established beyond the base cost, as discussed above. These are the use or utility, esthetic, and need value evaluations. In a human economy there are factors above and beyond the mere cost value that we see expressed in, for example, the metabolism exchanges discussed in Chapter 12. The human economy allows for functions beyond mere energy flow that support aspects such as development (improvement/evolvability) and psychological support (esthetics and the hierarchy of needs).

Use Value, Utility

Let's say that every plow that was ever produced in pre-industrial civilization took the exact same amount of energy to make (emergy value). The plow produced by blacksmith Bob was fundamentally the same as that produced by blacksmith Ray. Then in a balanced economy the total production of Bob and Ray output would equal the total needs of the society they served. But suppose Bob invented a new shape for a plow that allowed a single ox, as opposed to two oxen, to do almost the same amount of work in the same amount of time, i.e. be more efficient for the farmer. Bob is probably justified in asking a higher price for his plows than is Ray. And farmers that can afford to pay that higher price (because they saved more of their earnings in the past) can pay the premium. It may be the case that Bob's emergy investment is no different than Ray's, but the end result, the production costs of a crop, result in a net saving to society. In other words, Bob's efforts (and inventiveness) increased the total free energy to society.

The use value, and the use value premium[20], is a result of how much total free energy is added to the society (system) as a result of any advantage that asset (tool) provides the production processes that use it. The price charged for an asset that increases the overall free energy in the system might be viewed as a kind of profit, but it is not the same as in a current market – what the buyer is willing to pay. The price in this case is established by the benefit to

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[19] See the Wikipedia article: https://en.wikipedia.org/wiki/Theory_of_value_(economics) for background. Accessed 10/30/2019.

[20] See the Wikipedia article: https://en.wikipedia.org/wiki/Use_value for background. Accessed 10/30/2019.

society, not a whim of buyers and possible deceit by sellers. There must be a quantifiable benefit to society in the form of increased usefulness in the form of increased free energy available.

The benefit to society can be realized either in the form of reduction of work effort for the same production, or increased development of culture (i.e. more art). The society does not 'need' to grow as a result. It can enjoy more leisure or more esthetics as a result of increasing the amount of free energy available to a particular level of production.

Esthetic Value

Human beings enjoy life. We cannot begin to address the effects of affective influences on human productivity. But there is now a body of evidence that humans who engage in esthetic activities (especially group activities) are ultimately more productive in work activities. People who have recreational time simply do work more efficiently. So even though esthetics seem to be counter-economic, in fact they are contributory to enhanced economic outcomes.

This extends to assets that have not just functional value but esthetic value as well. We can see this in early humans' design of ornamental accouterments to tools like knife handles carved from ivory or bone. Some of the earliest artifacts of humanity include seemingly purely esthetic relics such as the cave paintings in Paleolithic Europe or the fertility figures[21] of that time. Clearly esthetic qualities have been an important value to humans for a very long time.

It is not surprising then that esthetic qualities factor into the valuation of assets. Today humans seek all kinds of artifacts that are not only functional but "beautiful" as well. We suggest that this tendency supports psychological well-being and as such has economic value. Happy humans are more social (and social organization is at the base of success of the species) and more productive. They therefore tend to optimize the use of free energy for the good of the whole society.

Need and Exchange Value

There is another aspect of value above and beyond the utility or esthetics used in the calculus of price. People trade assets because they have a need for what the seller is selling and less need for the asset they seek to trade. In a happy situation the various values of the to-be-traded assets mentioned above, will be essentially the same and the trade will make both parties prosper. The problem comes in when, say the use value, of one asset exceeds that of the proffered asset. The need doesn't go away so the buyer and seller may have to negotiate. In today's market economy this can lead to sellers trying to hide real costs of production or promoting a higher utility than will actually be realized so as to boost the price. In a more ideal situation, the buyer should understand what the value of the asset to-be-bought is and realize they

[21] See the Wikipedia article: https://en.wikipedia.org/wiki/Venus_of_Willendorf for an example. Accessed 10/22/2019.

may need to sweeten the deal with some additional asset to exchange so as to even the transaction.

On the Consideration of Value in Economics

On the basis of the above analysis we have a basis for assigning value to economic products in the human economy. Value is based on what maintains or improves human life, not in terms of (as is the case now in Western societies) growth of possessions and in the overall economy, but in terms of what contributes to human psychological well-being. Wealth, then, is that which supports human happiness and contentment, not that which may seem to promote status on the basis of ownership of frivolous assets. Status enhancement has always been a human desire, of course, but one would hope that humans build their status on the basis of their deeds rather than their possessions.

Mitochondria do not compete with one another for status. Nor do ribosomes. Nor do lungs or any other living organs or organisms. Competition is based on energy flow and selection

Proper Role of Savings and Surpluses

Wealth accumulation for its own sake has become, mixing source languages, both the *sine qua non* and *raison d'être* in neo-liberal capitalism. However, it should be noted that the definition (or conception) of wealth includes the monetary value recorded on some account (today digitally) and not necessarily true physical wealth. Even real-estate values are merely estimates of asset holdings in monetary units, and are based on some market-based perceptions. A house is worth absolutely nothing in monetary terms unless there is someone to buy it. The same goes for the value of corporate stocks. This is 'paper' wealth that is meaningless without both a market and gullible agents to buy and sell. All such market-based mechanisms for valuation are subject to bubble phenomena and crashes – then where does the wealth go?

Real wealth means the holding of physical assets the valuation of which is based on the criteria given above (e.g. use value). In a sustainable CAES economy the values are established by the real criteria. Prices of units of the assets do not go up because there is a higher demand (though the amount of energy expended to produce the assets will go up). There are no winners or losers in competition to acquire necessaries as in current market-based exchanges.

Some commodities, such as foodstuffs, may from time to time, be produced in surpluses above immediate demand. Care must be taken (logistical management) to optimize production. For example, in the case of some foodstuffs (e.g. grains), excesses in one year can be saved as insurance against a bad year following.

Money, while not actually a commodity, might also form a surplus if a seller, say of some commodity or esthetic objects, enjoys a particularly efficient production and sells more than in a normal year. A bank can provide a service to hold such surpluses as savings. Again, the purpose of such a buffer is to provide insurance against future poor years or catastrophic asset losses (like a house burning down).

Both grain (as an example) and money savings might accumulate to a point that either the granary[22] or the bank can 'loan' some of the accumulation to help a member of the community improve a process or even start a new enterprise within the constraints of the module. This is a basic form of fractional-reserve banking in which a small portion of all account holders' savings are pooled for the loan. Unlike modern fractional-reserve banking, wherein banks, for example, are allowed to loan out larger than safe proportions of savings and where the effect is often said to increase the money 'supply,' this use of savings should be completely transparent with the account holders being made aware of and approving the loans to be made. Also, the loans would be considered only for improvements, as in the potential increase in free energy as described above in the section on Use Value. The manager of the granary or the banker may charge a small fee to account holders and borrowers for their services just as any other provider of a service, but no 'interest' would be paid to account holders nor to the bankers and granaries.

The purpose of surpluses (when the occur) and savings should strictly be viewed as a buffer against unforeseen circumstances that invoke, for example, repair activities. Another use of excesses would be to support non-producing members of the community, such as the elders participating in councils (see below).

Social Organization

Related to the design for faulty agents' concepts given above, the actual physical layout of a social unit[23] will do much to lessen the kinds of stresses on individuals that allow faulty decision-making to dominate humans as agents. A first principle here is that a social unit should not have more people in it than a normal person should interact with on a daily basis. For example, Robin Dunbar (1992) suggested that there is something like an optimal number of individuals in a group. He used the size of the neocortex of various primates and correlated this measure with the mean number of social contacts in the 'troop.' According to his index human social units should have a mean size of around 150 individuals. Other anthropological studies of prehistoric and contemporary tribes do show that the number of people grouped together does tend to be in a range of 100 to 200, so Dunbar's number, as it is called, seems about right[24]. The psychological theory behind Dunbar's number and the size of the neocortex is that that is the number of close personal contacts that the human brain evolved to process. One individual may be able to handle, on average, that number of mental models of other people.

[22] See the Wikipedia article: https://en.wikipedia.org/wiki/Granary for background. Accessed 11/17/2019.

[23] A 'unit' of society takes on somewhat different meanings based on the level in the hierarchy as explained below. The term 'module' is basically synonymous with unit.

[24] Other researchers, using different approaches, have come up with numbers much larger but not even an order of magnitude so. See the Wikipedia article: https://en.wikipedia.org/wiki/Dunbar%27s_number for background. Accessed 10/31/2019.

Design Considerations: Modularity and Hierarchy

Briefly we consider several factors that will be important in the design of a social system. These will be expanded later below. What we will describe is an architecture that actually reflects the natural one that humans originally had at some stage of their cultural evolution, what is called, by Daniel Quinn (2000), a "new tribalism." Quinn sees this as the next stage in cultural evolution, restoring human relations in social units of appropriate size and complexity. This basic organization of indigenous cultures arose naturally as human populations increased and spread around the globe. It was a successful strategy for governing larger numbers of ethnically or genetically related people. And it carried through the early stages of the Agricultural Revolution into the era of what we now call civilizations. It evolved in a bottom up fashion as would be expected for an ontogenic process.

One of the most successful ways to manage complexity and reduce the impacts of occasional dysfunction in some components in a system is to design component subsystems as 'modules,' that is, bounded subsystems[25]. As we saw in Chapter 2 this is how nature evolved the complex systems we see today. Semi-independent modules may be linked by the kinds of connections (flows) demonstrated in Chapter 3 to form supra-modules. We will explore the various scale modules, but we can readily picture the way this might work for human social systems. The lowest level module can be considered a 'family,' however that is constituted, or, more generically, a 'domicile.' Groups of domiciles may constitute the next higher-level module, for example, a village or community using Dunbar's number as a guide to a reasonable size for a community module.

Likewise, a multiplicity of communities may be grouped into a larger-scale module (system) that might be called a 'tribe.[26]' These tribal units may be further grouped as will be discussed below. What is being described is a hierarchical network, modules composed of submodules down to a basic fundamental element; a system of systems. All modules starting at the very bottom of the hierarchy are connected by flows of communications and distribution of assets within the module. And modules are governed by a common hierarchical cybernetic structure as well as sharing principal aspects of culture. The flows are designed to allow specialization of modules at any level, and the distribution of goods and services in the same sense as we currently think markets work. The governance architecture can be the same for all modules within a given level and up through all the levels.

[25] In designs of mechano-electrical equipment modular design makes it possible to easily replace a faulty module. This is not a particularly useful benefit for social modules but in the event of a disease or other calamity striking a module, one can imagine seeding a new module as needed.

[26] The term here is used to designate a grouping that is very similar in nature to social systems found in many indigenous peoples, including the American natives. See the Wikipedia article: https://en.wikipedia.org/wiki/Tribe for background on the anthropological use of the term and other similar terms meant to indicate relative size and complexity of social groupings.

Figure 15.1 shows a schematic representation of the modular design approach. It shows the basic structure of a social module composed of submodules, communications and asset flows. And it hints at the governance architecture we will be advocating (and mentioned above regarding a brain-like one). The figure includes the idea of a module wherein submodules may act as interfaces for the import of asset resources and export of product/byproduct assets as previously described. These flows would represent internal flows at the next higher level in the hierarchy.

Also shown in the figure is a hint of the governance architecture in the form of a module council. The council, to be explained below, is the coordinator for the submodules and has the responsibility for strategic management of the module.

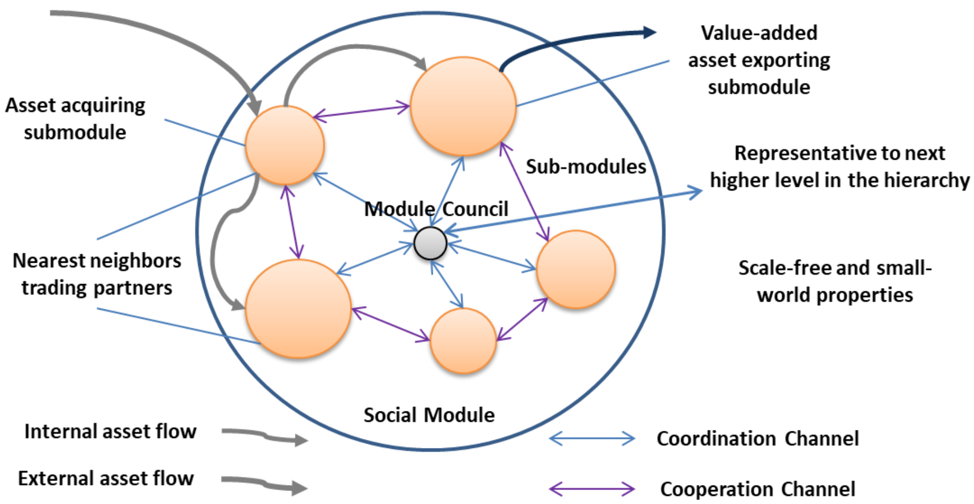

Fig. 15.1. A social module (at any level in the hierarchy) is composed of submodules that can share/trade assets and communicate with one another.

We can now outline several modules at increasing levels in the hierarchy. Later we will describe their nested relations in the hierarchy of modules.

Domiciles

It might be useful to think of individuals as atomic processes. The lowest-level module we will consider we're calling a 'domicile' or household. As stated above this is likely synonymous with 'family' so long as we don't think of strict blood-relations defining the bounds. A domicile is also a basic unit of work and reproduction.

While it is not likely that domiciles could be self-sustaining units, in a low-power world, most food production will likely be done by domiciles, as farming and food preserving processes. They would also be the locus of population renewal. As elders die off, babies would be conceived for replacement in a steady-state population.

Domiciles are the locus of operational-level governance, with logistics relating to farming and other domestic tasks. Tactical governance involves interactions with other domiciles in the community.

Communities

A collection of interacting domiciles constitutes a community. The physical arrangements of domiciles within a community could vary widely, from a spread-out farming community to a clustered set of domiciles like a village. The determinant would be based on the geography and main sorts of activities of the community. As a subsystem of the next level, the tribe, communities may very well engage in activities other than just farming, such as crafts and products meant for trade with other communities. Since communities within a tribe may be relatively near in space, the opportunities for communities to take advantage of local specific resources to create (or grow) commodities that other communities would value. Thus, the activities of communities is similar to the metabolism of cells (see Chapter 12) that produce export commodities/products.

Communities need not be completely self-sufficient either. However, the collective production of food and artifacts of several communities should provide a level of self-sufficiency to the next level up.

Communities are also the locus of coordination governance for the domiciles. The community council (see below) would be expected to help the community to achieve a relatively high level of self-sufficiency. The reason is that in a changing world (e.g. climate change), there are always threats to domiciles and whole communities. In the event of a calamity to one community, there should be sufficient resilience in the others to not be impacted by the loss.

Additionally, communities are the providers of infrastructure services, such as inter-domicile communications and education, at least through what we would call ‘high school.’

Tribes

The collection of some number of communities (see below for an analysis of numbers at each level) can share a larger geographical region and many aspects of culture. We will use the term tribe to describe this modular unit.

There are any number of structural organizations that a tribe might embody. For instance, one community in the tribe may act as a kind of capital or central governance specialist where the tribal council can meet. Presumably such a community would be like a village in which the domiciles contribute to the support requirements for representatives from the various other communities living for extended periods. We might also expect the other clerical trappings of a government center for record-keeping and analysis of data gathered from the other communities for purposes of coordinating their activities.

The tribal level might also be expected to be responsible for organizing the higher education needs of young adults (colleges). This could be accommodated in the same community as the governance but could also have its own specialized community.

Nations

The logic of building up larger collections of modular units to handle the coordination among the lower level modules continues with the collection of some number of tribes as a nation. Whereas tribes probably share a similar environment over some geographic range, it is likely that different tribes will experience different ecological conditions. At the same time a mechanism for providing coordination among tribes would be useful for communications and cultural exchanges. Tribes may undergo independent cultural evolution (but within the global guidelines for sustainability discussed below) and be able to share ideas and, especially, new knowledge. The amount of commodity trade between tribes would probably be more limited since the distances between them would likely only allow small material flows owing to the limits of energy available to support long-distance transportation.

As with the previous units, the governance of a nation is through a council of representatives from the various tribes. The same basic structure (which now could be described as ‘fractal’) of specialist tribal units for centers of governance and higher education (e.g. universities) would allow for the centralized processes to be tightly coupled while maintaining an overall distributed architecture.

Federations

In all likelihood the population distributed among nations might need an additional level of coordination that could be described as a federation (collection) of nations. Again, the considerations are based on geographic distributions, for example continent-scale. As with the prior modules the general pattern of the modular design, including its governance, will be based on a council of national representatives and any additional coordination facilities that would be needed. As with the above descriptions, the main flows between subsystem modules would be messages for coordination and sharing new knowledge.

Global HSS

We imagine that the whole hierarchical structure terminates in a global HSS having the self-same architecture of those below.

Governance

The governance archetype model of Chapter 11 will provide us guidance for developing a workable governance system for the HSS. Most of the current governance systems are too monolithic and overly complex no matter the underlying political philosophies. The constitution that worked well for the early United States as a representative democracy seems to be failing the current actual polity (Brennan, 2016). The design of three branches of government does follow from the three primary duties of a government, but the implementation of the legislative, executive, and judicial branches has long been problematic and becomes more so as the overall size of the country, in population, and the complexity due to cultural and technological innovations increases with time. This model does not scale well. In the US, the central, federal government is not an adequate coordinator for the various state government (that take on the same form as the federal government). Superficially there appears to be a hierarchy in the sense of the HCGS, but in fact this is not the case. Even less so for the various local governments, counties and cities.

We will not dwell on the inefficiencies and ineffectiveness of the current broken system. What we will do is explore a completely different vision of what governance of the HSS should be. Let us call this vision a distributed HCGS wherein true political power comes from the lower modules in the hierarchy. This will be a true democracy.

Democratic Sapiocracy

Democracy as currently understood is the idea that all citizens of a polity should be able to participate in decisions about who should attain positions in government (and of ‘power’). Egalitarian

The problem with this conception is that it depends critically on both the definition of ‘citizen’ and on the notion that whoever is a citizen is sufficiently educated (as well as thoughtful) to understand the workings of government (as in ‘civics’) and the norms and mores of the society. As has come to light in recent years, in some of the purported “greatest democracies,” such as the United States of America where suffrage is supposed to be universal, two critical issues are faced. First, there are known ways to suppress voting by certain groups, thus diminishing the idea of universal suffrage. Second, a significant proportion of the voting public is extremely ignorant in civil matters (Brennan, 2016).

Political philosopher Jason Brennan (2016) has proposed that a much more logical and efficient approach to political process is to adopt an “epistocracy,” or only allowing those citizens who demonstrate a basic knowledge of civics and awareness of potential policy options and candidate qualification to vote and hold office. He provides a number of arguments, especially the lack of knowledge by average voters, as to why democracy does not and cannot work in a society that is so huge and complex. But he thinks the solution is to require this basic level of knowledge (episteme) of citizens who want to participate. Given the recent events in American political process, there may be much to be said for this. Thomas Jefferson said "A Nation's best defense is an educated citizenry." And, the story goes, that as Benjamin Franklin, after participating in the writing of the US constitution, was asked by a woman "Well, Doctor, what have we got, a republic or a monarchy?". He replied "A republic, if you can keep it." He had been very worried that the electorate might not be able to sufficiently understand the political requirements needed of an informed citizenry. The electoral college was created as a safeguard against a majority of ignorant citizens electing ‘the wrong kind of president.’

However, knowledge by itself is a very tricky thing and can be interpreted in several ways, such as ‘facts’ which are subject to interpretation from different perspectives, e.g. evolution. Facts alone are not sufficient. This whole book has been about a very different kind of knowledge – understanding. This requires not just knowing facts, but also knowing how things work, how those facts interrelate. This is the domain of wisdom or sapience (Mobus, 2012, 2019). The proposal advanced here is that, just as groups and tribes of old were governed by a council of wise elders, the human social units should also be guided by councils composed of the wisest (which will generally mean the more senior members of the group). Wisdom is the accumulation of tacit knowledge gained over the lifetime of an individual providing they have the neurological equipment and mental capacity to acquire it. It is the basis of veridical judgements and intuitions guiding complex social decisions/problem-solving.

Let us call this concept sapiocracy (from the Latin “sapio,” meaning discerning, wise, and judicious, and the name given to our species, *sapiens*). That is the governance, especially at the strategic level, is provided by a small group of wise elders. Somewhat similar to Brennan’s concept of epistocracy, those who are chosen to lead are selected not just on the basis of their explicit knowledge but on their holistic tacit knowledge about how the world works, including how people work.

There is an age-old method for recognizing wisdom in people. You ask others in the social group who have had an on-going relationship and experience with the candidates (Sternberg, 1990a, 1990b). People, even young people, are often very good at recognizing wiseness (or sagacity) in other people. Within a domicile this could be as simple as the eldest member, say a grandmother, would represent the domicile in the community council. Then, in a community, the council members could, through deliberation, decide who they should send to the tribal council. This form of government and political process for selecting leaders is more democratic than the current examples of, say, representative democracies, especially those in which the wealthy have a disproportionate influence on the campaigning and voting mechanisms.

It is important to note that this is not meritocracy in the traditional sense. Leaders are not chosen on the basis, for example, of how successful they have been in life pursuits, nor the presumption of how ‘smart’ they are. What is needed in leadership is wisdom above cleverness.

Hierarchical Network of Modules and Councils

The hierarchy of social modules is depicted in Figure 15.2 below. The number of levels depicted is not suggested to be some absolute number. The point of this hierarchy is to keep each module at all levels manageable through limiting the number of participating submodules. So, if a community contains roughly 15 domiciles (with 10 individuals participating in an average domicile), which keeps the community population at Dunbar’s number, and then we can use a similar logic in determining the number of communities that come under a single tribe. Using the

Dunbar number as a guide, suppose the average number of communities in a tribal module is kept somewhere below 150. This is to keep the tribal council size at or below Dunbar's number. The total population of the tribe is <150 X 150 or approximately <22,500 individuals. Of course, this should probably be viewed as an upper limit for the purposes of keeping the size of a tribal module manageable. The number of communities in a tribe would more likely reflect the overall conditions of the geographical area, the local ecosystems, resource availability, etc. The total territory of a tribe, likewise, would be determined by the environmental conditions supporting the population.

This design principle is extended up to the collection of the whole HSS population.

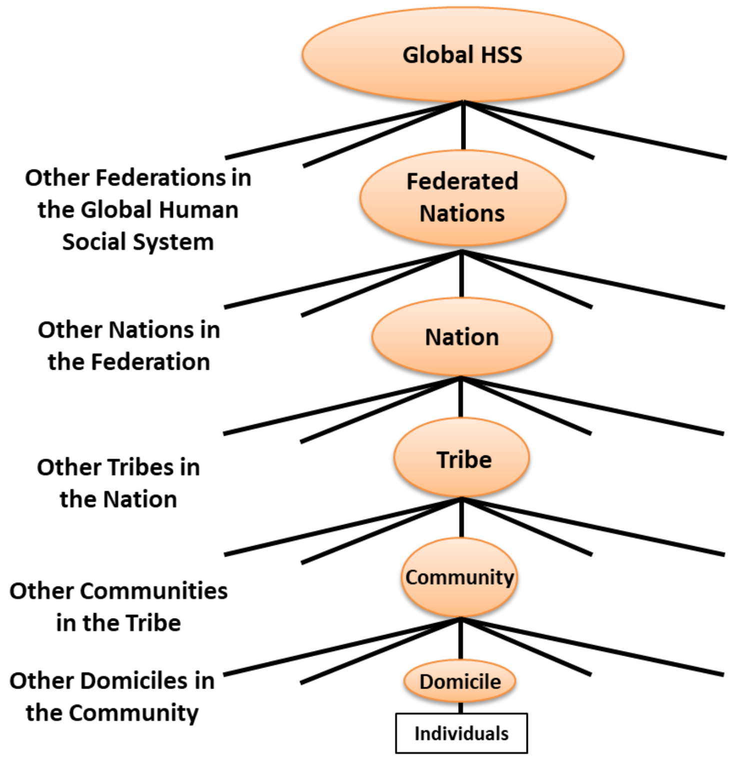

Fig. 15.2. The global HSS is based on a hierarchy of modular social units, as depicted in Figure 15.1 above, starting with domiciles (families and a few other individuals), which are collected into higher level modules, communities, and those in turn are collected into tribes and so on.

With appropriate population sizes in these modules distributed over sufficient land areas, the various communities can be spaced such that interactions between individuals on a daily basis would be kept to the level that does not put an overburden on a person's mental capacities. Similarly, the distribution of tribes, say by regional considerations would further buffer interactions between members inter-nationally.

The biggest advantage of this hierarchical, distributed modular, network design is that local processes are the dominant mode of operations and management. As opposed to a top-down government such as is seen in most countries today, the main form of governance starts with the community level.

Local Governance

In keeping with the ideal of democracy or universal participation in political and policy decision making, the governance of modules is basically local. Thus, the effective decision making is vested in the local council, meaning the council of the module type in the hierarchy. The vast amount of the power to affect life is vested in the community level. The purpose of higher councils is not to tell communities what they should do or how to live their collective lives. It is purely for the purpose of providing a coordination service, that is logistical support and appropriate tactical 'advice.'

Global Governance

From the standpoint of the global HSS, the role of governance is to observe both the Ecos and the HSS, the long-term behaviors, actions taken and consequences resulting, and attempting to understand the dynamics of the whole system. The ultimate role of the global council is to consider strategic moves that are meant to benefit the planet as well as humanity. This may manifest in the form of suggestions for tactical moves for the federations.

Likewise, the federation councils are monitoring some of the same considerations but for the scope of the federation of nations under their purview. The difference between the global and federation governance is mostly scale in space and time; the time scales of lower modules are shorter than for higher modules as a rule.

This pattern is recursively applied down to the community level. Upper councils are concerned with the sustainable operation of the whole module unit and provide logistic support, for example maintaining any needed infrastructure to allow sub-modules to cooperate and interact, and tactical suggestions (not laws and coercion) to the sub-modules in the interest of facilitating the whole module's interactions with other peer modules.

Module Governance Architecture

Integrated Governance: Social Behavior and Economy

Once upon a time the study of political and governance processes was integrated with the study of economic processes – political-economy. Today, main stream political science and economics are often studied almost independently and certainly with differing world views. This is remarkable since governments routinely intervene in economic processes in a number of ways. As is often observed, the so-called 'free market' has never actually been free of government interventions (Polanyi, 2001)[27]. Similarly, the economic processes are the sources of 'revenue' for the support of governments. So, it is odd to think of the two as separate domains. We did

[27] And as noted in several places, particularly Chapter 12, we have established the thesis that markets are not able to self-regulate as supposed by neo-classical and capitalistic views. So the notion that a free market could, in principle, govern itself without government intervention is a pure myth.

provide two archetype models, one of governance mechanisms (Chapter 11) and economy mechanisms (Chapter 12), but this was to show the particularities of two different kinds of processes. We also showed how these two models are related, or interrelated, and how governance applies to both civic and economic decisions and management.

Figure 15.3 depicts this co-equal relation between the three spheres of social activities.

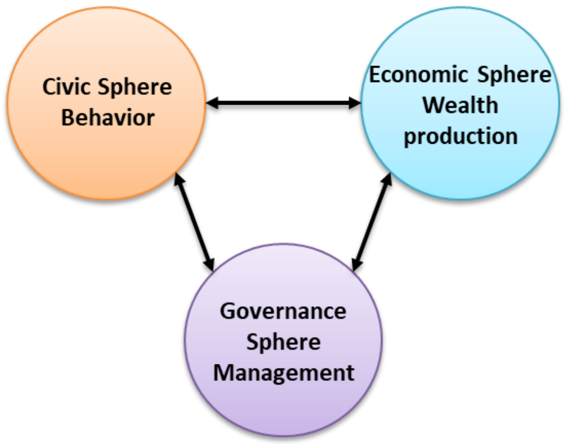

Fig. 15.3. Civic activities (interpersonal behaviors), economic activities, and governance are all interrelated and need to be considered as a whole.

In what follows we consider that the governance of a social module is embodied in a government structure that serves several necessary functions.

Functions of Government

We turn attention to the architecture of a government that fulfills the various functions of a government over both civic and economic activities. As with all systems we have examined in this work, we consider the subsystems and the flows of influence (messages) between them. Figure 15.4 provides a general systems overview of a government system. There are three basic work processes and two repositories/decision models.

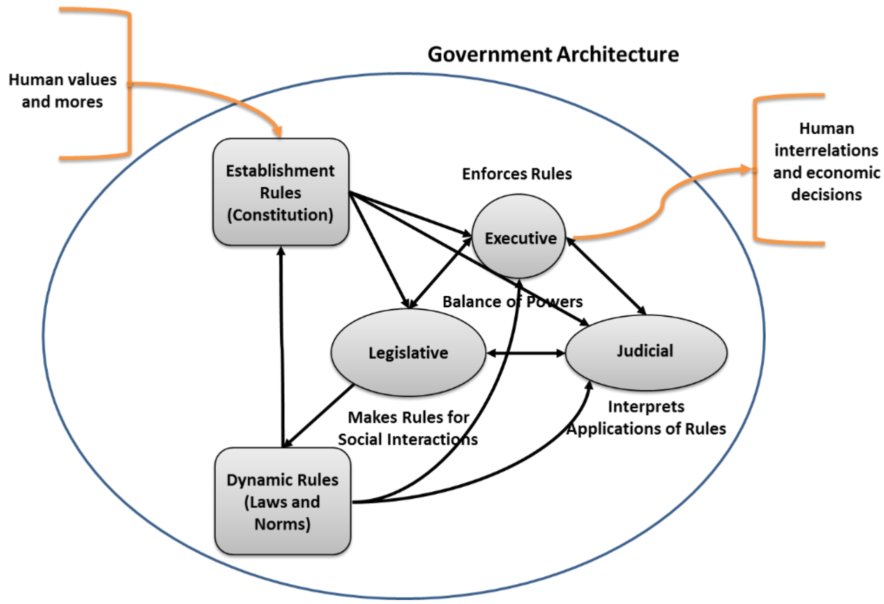

Fig. 15.4. The general architecture of government used by current political units.

Establishment Rules – Governance System Inputs

Unlike many system inputs from an environment the "establishment rules" or "constitution" are a result of a, generally, one-time flow. A society establishes its set of values and mores that *should* govern the body politic and establish a set of rules for the organization and general operation of the government structure itself. Such rules are considered stable for very long time frames, say the lifetime of the social module itself. The formal constitutions of many nation states today reflect these establishment rules.

While these rules are generally viewed as stable (and stationary), practical experience in an evolving society show that the rule base needs to also be an evolving, or learning, system. Changes to a constitution are rare in practice, but sometimes necessary to accommodate new conditions not anticipated by the originating values/mores that gave rise to them initially. There are several mechanisms used by nation states to achieve these changes. In the figure we show that such changes are guided by the body of "dynamic rules" (below).

Dynamic Rules – Governance Output to the Human Subsystem

Societies have been, historically, and are likely to continue to be evolving systems. Moreover, the establishment rules are often too general to handle day-to-day or even year-to-year changes in the system. As such they need to have a mechanism for producing and codifying rules that can, themselves, be changed dynamically. The repository shown in Figure 15.4 as "Dynamic Rules" constitute the laws and evolving mores of the society over time. These constitute the basic behavioral decision models used by individuals and institutions to conduct normal operations. These rules are subject to nearly constant revision, addendum, and deletions as the conditions within the module change over time. However, it should be noted that in a stable society, the rate of changes to rules, would be anticipated to be much lower than is observed today in most of the world's nation states.

Laws are generated by legislative action (below). They are the result of intentional design (through deliberation generally). Mores and norms are adopted more-or-less unconsciously by the spread of social memes. Once again, for a stable society in which novelty is encountered but slowly, these various rules of conduct would not be expected to change rapidly.

Executive

In most governments the executive branch (whether a dictator or a president) is required to "enforce" the rules, both establishment and dynamic. What enforcement entails today is dependent on the form of political model. In a dictatorship this might mean coercion under the threat of personal harm. In a democracy it could mean incarceration (for breaking the rules) or at least a stiff monetary penalty (for cheating in the economic system).

In the envisioned social system, under the assumption that with a much simpler and stable society people will be less prone to try to cheat, executive actions might look similar when cheating does occur, but more broadly it might be viewed as providing helpful corrective advice when citizens or institutions make mistakes. This follows from the philosophy that authority does not mean punitive power but higher wisdom and understanding.

Legislative

The role of the legislative branch of a government is to assess the societal situation and conditions and address any disparities that might be developing through the construction (systems engineering) of appropriate rules. This is fundamentally the modification of the decision models used by various decision agents in the civic or economic spheres. This is the adaptive process of a society, applied only when needed to adapt to changes in the environment.

In our current society we see this adaptive process working not just to adapt to external changes but to internal evolutionary changes within the society itself. For example, congresses need to adopt new laws to regulate the uses of new technologies or materials that have come into existence due to innovations within the society itself. For example, the establishment of the Environmental Protection Agency (EPA) in the US and the writing of environmental protection legislation have been the result of the development of numerous 'unnatural' chemicals, like plastics and biocides that have been shown to threaten the natural environment. We might call this second-order adaptation, but it is really just a form of evolvability.

Judicial

Judgement of the "correctness" of behaviors is a constant requirement of designing for faulty agents (as described above). All governments include a judiciary function for this purpose. There will always be differences of opinion and perspective among human agents and so there needs to be a mechanism for adjudicating (that is resolving) those differences when they arise.

Of course, for the current species of humans that includes a variety of anti-social behaviors that may arise as a result of the stress levels generated by the scale and complexity of industrial or even agricultural societies. We will not attempt to psychoanalyze modern society, but simply assert that there is ample evidence that crime and anti-social behaviors are high and that the complexity and failures of modern societies might be to blame. The competition that is fostered by a capitalistic society is a major source of stress and disagreements. In the envisioned social system there is no need for that kind of competition.

A judicial function will probably always be needed in any governmental system. However, in a scaled modular social unit, it is anticipated that the need for adjudication or either civic or economic misbehavior will be much less than we currently experience.

Governance in the Social Module

What, then, would the governance of a systemic social module look like? In Figure 15.5 we offer one possible model. The social module already consists of a set of operating sub-modules (the various trades in a community or specializations in a tribe, etc.) and these are governed by a modular government. Here we show how the functions discussed above are handled and add a crucial new function.

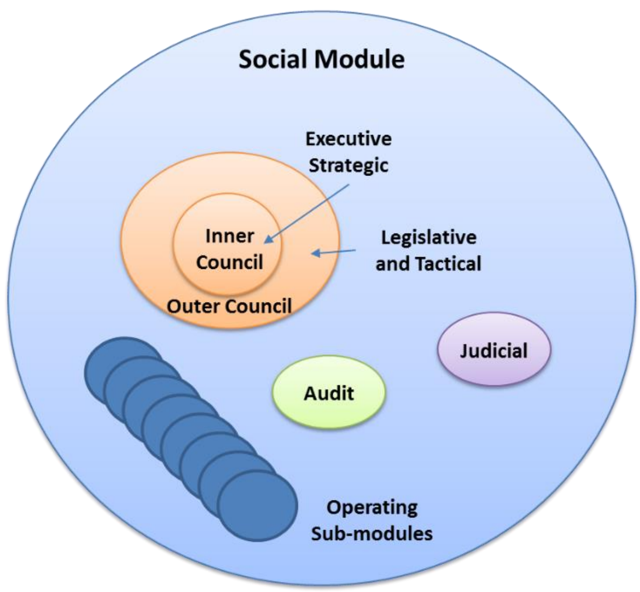

Fig. 15.5. A general architecture for a social module would provide for the four main functions of government and cover the operating (work processes) submodules.

In this figure we show the governing council as discussed previously, but having a specific structure that allows for the implementation of some of the functions described above. We also show the judicial function as separate from the council and a new function that is analogous to the “fourth estate” in democratic governments, what we have labeled as the “audit” function.

The council has been organized as an “inner” and “outer” councils with different roles as explained below. As the reader may recall, councils at all levels will consist of from 50 to 150 members (depending on the level in the hierarchy and the number of actual sub-modules). The design suggested in Figure 15.5 assumes that some smaller number of, presumably the wisest members of the council, are elected to the inner council and that that unit is responsible for the strategic decision-making for the whole module and for the executive functions of government. The outer council would fulfill the role of legislative body and be concerned with tactical governance of the module. The judicial function could be handled by a rotating sub-council of the regular council members. They would recognize their role for the period during which they served in that role.

What is labeled as the “audit” function in this model is essentially the role supposedly played by the fourth estate or the “press” in modern societies. In this case the role is closer to that of internal auditors in large corporations and other institutions. The audit role is to monitor the actions taken by the other three branches of government (assuming complete transparency) and report these to the rest of the module citizens. This is the basis for citizens to consider who among their members are truly wise. That is, citizens would have complete access to information regarding how their governors were performing and be able to thus make judgements on how well their current set of leaders are serving the whole module. This is another aspect of designing around potentially faulty agents.

Conclusion

The human social system that evolved at the end of the Pleistocene epoch provided a natural structure and function for the general well-being of individuals. That doesn’t mean life was not ‘hard’ in the sense that survival was not assured and much work needed to be done to stay alive. But humans had also evolved some unique talents that made them significantly different from even their nearest cousins, the other great apes. They had language, collective intentionality, and a capacity to imagine and construct more complex tools out of at-hand materials. Starting from having nothing but innate concepts of how the world worked (i.e. physics) they gradually developed the ability to invent ever more clever tools and methods for living. During the whole time leading up to, roughly, the Upper Paleolithic[28] humans had been evolving sapience, the capacity to accumulate a wealth of implicit knowledge, strategic and systemic thinking, and a heightened sense of moral sentiment. Then, around 10,000 years ago something happened. Humans discovered agriculture and everything changed. The further development for strategic thinking would seem to have been sidetracked in favor of short-term operational and logistical thinking. And the bulk of the populations that arose out of nascent civilizations tended to be selected precisely for their lack of higher order thinking.

[28] See the Wikipedia article: https://en.wikipedia.org/wiki/Upper_Paleolithic for background and time frames. Accessed 11/21/2019.

The modern, technologically enhanced, world is the outcome of ten millennia of cultural evolution, intentional-organization and various selection mechanism for determining the ‘success’ of artifacts. The most potent selection force of the last two to three hundred years has been the mental state induced by capitalism, the desire to accumulate wealth for its own sake. As a result, the vast majority of people, today, believe that endless economic growth is a ‘good’ when in fact it is the thing that will likely destroy civilization and is the cause of what has been called the Fifth Mass Extinction.

In this chapter we have considered how systems science, its major principles, and systems design and engineering might be applied to the human social system. Using the archetype model of a complex adaptive and evolvable system, a system that is designed to be sustainable, persistent, and stable in the face of changes in climate and biota, we found that the structure of a global HSS to be essentially like the one that existed at the end of the Upper Paleolithic. That structure involves modular groups in a hierarchy of modular units, similar to tribal organizations of so-called primitive aboriginal peoples.

The purpose of this exercise was dual. First, we wished to show the contrast between what a CAES-based HSS and our modern nation-state-based organizations would be in the hope that more rational decision-makers, if they exist, could consider what would it take to transition from that in which we live now to that which would fulfill the CAES ideal. Second, in the event that the current system implodes and civilization as we know it crashes, the ideas promulgated here might serve as a blueprint and guide for what to do to recover humanity.

If these pages survive.

References and Further Reading

Anderson, WT (2004) *All Connected Now: Life in the First Global Civilization*, Westview Press, Boulder CO

Brennan, J (2016) *Against Democracy*, Princeton University Press, Princeton NJ

Coen, E (2012) *Cells to Civilizations: The Principles of Change that Shapes Life*, Princeton University Press, Princeton, NJ

Costanza, R, Cumberland, J, Daly, H, Goodland, R, & Norgard, R (1997) *An Introduction to Ecological Economics*, St. Lucie Press, Boca Rotan FL

Crist, E (2019) *Abundant Earth: Toward an Ecological Civilization*, University of Chicago Press, Chicago

Crosby, AW (2007) *Children of the Sun: A History of Humanity's Unappeasable Appetite for Energy*, W. W. Norton & Company, New York

Daly, HE & Townsend, KN (1993) *Valuing the Earth: Economics, Ecology, Ethics*, The MIT Press, Cambridge MA

Daly, HE & Farely, J (2010) *Ecological Economics, Principles and Applications*, 2nd Ed., Island Press, Washington DC

Diamond, J (2005) *Collapse: How Societies Choose to Fail or Succeed*, Penguin Group, New York

Donald, M (1991) *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition*, Harvard University Press, Cambridge, MA

Dunbar, RIM (1992). "Neocortex size as a constraint on group size in primates", *Journal of Human Evolution*, **22**:6, 469–493. doi:10.1016/0047-2484(92)90081-J

Ferguson, N (2008) *The Ascent of Money: A Financial History of the World*, The Penguin Press, New York

Galbraith, JK (2014) *The End of Normal: The Great Crisis and the Future of Growth*, Simon & Schuster, New York

Gilovitch, T, Griffin, D, & Kahneman (2002) *Heuristics and Biases: The Psychology of Intuitive Judgment*, Cambridge University Press, Cambridge UK

Gordon, RJ (2016) *The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War* (The Princeton Economic History of the Western World), Princeton University Press, Princeton, NJ

Gazzaniga, MS (2005) *The Ethical Brain*, Dana Press, New York

Grinspoon, D (2016) *Earth in Human Hands*, Grand Central Publishing, New York

Hall, CAS, Cleveland, CJ, & Kaufmann, R (1986) *Energy and Resource Quality: The Ecology of Economic Process*, John Wiley & Sons, New York

Hall, CAS & Klitgaard, KA (2012) *Energy and the Wealth of Nations: Understanding the Biophysical Economy*, Springer, New York

Harari, YN (2011) *Sapiens: A Brief History of Humankind*, Vintage Books, London

_________ (2017) *Homo Deus: A Brief History of Tomorrow*, HarperCollins Publishers, New York

Hodder, I (2012) *Entangled: An Archaeology of the Relationships between Humans and Things*, John Wiley & Sons, New York

Homer-Dixon, T (2006) *The Upside of Down: Catastrophe, Creativity, and the Renewal of Civilization*, Random House Canada, Ontario

Hughes, TP (2004) *Human-Built World: How to Think About Technology and Culture*, The University of Chicago Press, Chicago

Jackson, T (2009) *Prosperity without Growth: Economics for a Finite Planet*, Earthscan, London UK

Kahneman, D (2011). *Thinking Fast and Slow*, Farrar, Straus, and Giroux, New York

Keen, S (2011) *Debunking Economics - Revised and Expanded Edition: The Naked Emperor Dethroned?*, Zed Publishing, New York

Klein, N (2015) *This Changes Everything: Capitalism vs. Climate*, Simon & Schuster, New York

Kolbert, E (2015) *The Sixth Extinction: An Unnatural History*, Picador/ Macmillan Publishers, New York

Maslow, A.H. (1943) "A theory of human motivation". *Psychological Review*. 50 (4): 370–96.

Meadows, DH, Meadows, DL, Randers, J, and Behrens III, WW (1972) *The Limits to Growth*, Potomac Associates, Washington DC. Available online at: http://www.donellameadows.org/wp-content/userfiles/Limits-to-Growth-digital-scan-version.pdf. Retrieved: 10/20/2016

Meadows, DH, Randers, J, Meadows, DL (2004) *Limits to Growth: 30-Year Update*, Chelsea Green Publishing, White River Junction, VT

Miller, JG (1978) *Living Systems*, University of Colorado Press (1995 edition), Niwot, CO

Miller, JH & Page, SE (2007) *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*, Princeton University Press, Princeton NJ

Mobus, GE (2012). "The Evolution of Wisdom", *Science, Wisdom, and the Future: Humanity's Quest for a Flourishing Earth*, Collins Foundation Press, Santa Margarita, CA. pp 83-89.

_________ (2017). "A Framework for Understanding and Achieving Sustainability of Complex Systems", *Systems Research and Behavioral Science*, **34**:5, John Wiley & Sons, Ltd, doi: 10.1002/sres.2482.

_________ (2018) "A Systems-Based Architecture/Design for the Human Social System", *Systems Analysis in Economy*, Moscow Finance and Economics University, Moscow, ORCID: https://orcid.org/0000-0001-8145-0908

_________ (2019) *A Theory of Sapience: Using Systems Science to Understand the Nature of Wisdom and the Human Mind*, Currently available online, hosted by The Millinium Alliance for Humanity and the Biosphere at Stanford University, https://mahb.stanford.edu/library-item/theory-sapience-using-systems-science-understand-nature-wisdom-human-mind/ . Accessed 10/7/2019. In preparation for print edition.

Mobus, GE & Kalton, MC (2014) *Principles of Systems Science*, Springer, New York.

Montgomery, DR (2007) *Dirt: The Erosion of Civilizations*, University of California Press, Berkeley CA

Meuleman, L (2008) *Public Management and the Metagovernance of Hierarchies, Networks and Markets: The Feasibility of Designing and Managing Governance Style Combinations*, Springer, New York [“how do successful public managers design and manage combinations of hierarchical, network and market governance? In other words: what is their rationale to apply metagovernance?”]

Nissen, HJ, Damerow, P, & Englund, RK (1993) *Archaic Bookkeeping: Early Writing and Techniques of Economic Administration in the Ancient Near East*, The University of Chicago Press, Chicago

Nowak, MA & Coakley, S, eds. (2013) *Evolution, Games, and God: The Principle of Cooperation*, Harvard University Press, Cambridge MA

Odum, HT (2007) *Environment, Power, and Society for the Twenty-First Century: The Hierarchy of Energy*, Columbia University Press, New York

Odum, HT & Odum, EC (2001) *A Prosperous Way Down: Principles and Policies*, University Press of Colorado, Boulder, CO

Orr, DW (2004) *Earth in Mind: On Education, Environment, and the Human Prospect*, Island Press, Washington DC

Piketty, T (2014) *Capital in the Twenty-First Century*, (translated by Goldhammer, A), The Bellknap Press of Harvard University Press, Cambridge MA

Polanyi, K (2001 edition) *The Great Transformation: The Political and Economic Origins of Our Time*, Beacon Press, Boston

Qualman, D (2019) *Civilization Critical: Energy, Food, Nature, and the Future*, Fernwood Publishing, Halifax

Quinn, D (2000) *Beyond Civilization: Humanity’s Next Great Adventure*, Broadway Books, New York

Rothschild, M (1990) *Bionomics: Economy as Ecosystem*, Henry Holt and Company, New York

Sawyer, RK (2005) *Social Emergence: Societies as Complex Systems*, Cambridge University Press, Cambridge UK

Scott, JC (2017) *Against the Grain: A Deep History of the Earliest States*, Yale University Press, New Haven

Senge, P (2006) *The Fifth Discipline: The Art and Practice of the Learning Organization*, Second Edition, Doubleday, New York

Seung, S (2013). *Connectome: How the Brain's Wiring Makes Us Who We Are*, Mariner Books, New York

Smith, JM & Szathmáry, E (1995) *The Major Transitions in Evolution*, Oxford University Press, Oxford UK

Smith, E and Morowitz, HJ (2016) *The Origin and Nature of Life on Earth: The Emergence of the Fourth Geosphere*, Cambridge University Press, Cambridge UK

Sober, E & Wilson, DS (1998) *Unto Others: The Evolution and Psychology of Unselfish Behavior*, Harvard University Press, Cambridge MA

Sporns, O (2016). Networks in the Brain, The MIT Press, Cambridge MASuddendorf, T (2013) *The Gap: The Science of What Separates Us from Other Animals*, Basic Books, New York

Sternberg, RJ (ed.) (1990a) *Wisdom: Its Nature, Origins, and Development*, Cambridge University Press, New York.

Sternberg, RJ (1990b) "Wisdom and its relations to intelligence and creativity", in Sternberg, Robert J. (ed.) (1990, pp 142 - 159).

Streeck, W (2016) *How Will Capitalism End? Essays on a Failing System*, Vesro, New York

Surowiecki, J (2004) *The Wisdom of Crowds*, Doubleday, New York

Tainter, JA (1988) *The Collapse of Complex Societies*, Cambridge University Press, Cambridge UK

Tomasello, M (2014) *A Natural History of Human Thinking*, Harvard University Press, Cambridge MA

___________ (2016), *A Natural History of Human Morality*, Harvard University Press, Cambridge MA

Türke, R-E (2008), *Governance - Systemic Foundation and Framework*, Springer, New York.

Vignieri, S & FahrenKamp-Uppenbrink, J (2017) “Ecosystem Earth”, *Science*, 21 April, 2017, Volume 356, Issue 6335, p 258

Volk, T (1998) *Gaia's Body: Toward a Physiology of Earth*, Springer-Verlag, New York

______ (2017) *Quarks to Culture: How We Came to Be*, Columbia University Press, New York

Wallerstein, I (2004) *World-Systems Analysis: An Introduction*, Duke University Press, London UK

Westneat, DE & Fox, CW (2010) *Evolutionary Behavioral Ecology*, Oxford University Press, Oxford UK

Wiener, N (1950) *The Human Use of Human Beings*, The Riverside Press (Houghton Mifflin Co.), New York

Wilson, EO (2013) *The Social Conquest of Earth*, Liveright, New York